

CARPENTRY & JOINERY



M.T. TELLING

PITMAN

A BOOK for students and apprentices in the building industry covering the general principles of Carpentry and Joinery. Special attention has been given to Workshop Practice, Woodworking Tools and Materials, General Construction, Measurement and Drawing, etc.

The treatment is sufficiently comprehensive to cover the requirements of the Intermediate Examination of the City and Guilds of London Institute.

"This book is an excellent contribution to the Secondary Technical Building Series; indeed, it may equally take its place among the better type of book which has been written on this subject during recent years."
—TECHNICAL JOURNAL, Sept. 1950.

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—BUILDING INDUSTRIES, Mar. 1950.

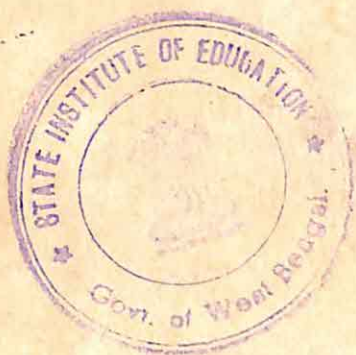
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THE BUILDING STUDENT'S SERIES

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CARPENTRY AND JOINERY



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BY

M. T. TELLING

FELLOW OF THE BRITISH INSTITUTE OF CERTIFIED CARPENTERS



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AUTHOR'S PREFACE

It has been said that man is a lazy animal, and his need for fashioning wood has always urged him to find easy ways of doing so. Whether the machines he employs are hand or power driven, thought and skill are still required. Mass-produced joinery may be an essential feature of modern building, but the repair and restoration of buildings put up in more leisurely days and the building of churches and of important national and municipal works will always call for the exercise of craft skill. It is safe to assume that well-trained craftsmen capable of exercising individual initiative in carrying a job through to a successful conclusion will always be most valuable members of the community, however mechanized our lives may become.

The community is beginning to appreciate its dependence upon the skill of craftsmen who possess pride and a sense of responsibility in their respective trades for the supply of all things needful to civilized life. It is hoped that it will not be long before it is also appreciated that the *act* of producing is just as important as the resulting product, and that the greatest possible number of our young people should have the opportunity of proving for themselves the satisfaction to be gained from creative work in natural materials.

The building industry builds houses; but it also builds sturdy reliable characters for those engaged in it. The idea of prefabrication is not new. It has been tried before in times of stress, found wanting, and largely scrapped. May we not hope that traditional building will again provide that much to be desired opportunity for craftsmanship?

The work which follows provides a basis for the study of the craft of carpentry and joinery along traditional lines. Indeed, it is difficult to visualize any other approach. In the early stages particularly, all operations should be done by means of hand tools, even to ripping the material from the plank. A true craftsman does not stand helpless in the absence of power-driven machinery; nor, on the other hand, does he scorn to employ it to cut down unnecessary drudgery.

Carpentry and joinery is a great and traditional craft, and any lad who enters it may well feel proud to carry on the good work of countless generations of craftsmen. May not our generation, too, leave to those that follow some reminder of the pride of its craftsmen in work well done?

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INTRODUCTION

THIS volume is intended for students in attendance at secondary technical schools for building. Most youths who enter such a school will have had at least a course in educational handwork—either woodwork or metal work, and possibly both.

In this event a youth will have had some practical acquaintance with the working of wood and will have been introduced to mechanical drawing and to freehand drawing (free sketching). It may be assumed, then, that a junior student who has selected carpentry and joinery as his particular building craft will enter upon the study with at least a groundwork knowledge of and reasonable practice in drawing, marking out and bench work. All the ordinary bench tools will have been used, their names will be familiar and many of their uses will be understood.

The following suggested course assumes this preparation to have been made; if not, introductory study and practice will be necessary and should be planned to suit the particular circumstances.

Every teacher is desirous of developing a detailed and orderly course of instruction which he builds up from his personal knowledge and experience. The intention of this book is to assist the teacher in the process of developing a course by the presentation of subject-matter which has been selected and treated from an experienced teacher's point of view. It is also intended to be helpful to the young student by encouraging personal reading and individual thought.

The craft of carpentry and joinery varies much in its range and standard in modern practice. A well-trained and ambitious building craftsman would not be satisfied to confine his sphere of training and knowledge to one section of the subject, even though the trend of present-day production is towards specialization. Carpentry and fixing may tend to be sharply separated from joinery production and the latter to be subdivided into specialist branches, but all aspects of the

craft can and should be mastered by the craftsman who desires a sound training.

The craft work which can be introduced into a secondary technical school for building is limited by the fact that it is one portion of a course intended to have a broad and truly educational basis, which must be kept well to the fore in planning and conducting it. Since most of the secondary technical students who enter the building industry as craftsmen will be encouraged to work for well-established qualifications such as the certificates of the City and Guilds of London Institute, this book is made comprehensive enough to carry a student to the standard of attainment required by the Intermediate Examination. The book is written largely for individual use and can be so utilized, to the advantage of both student and teacher, if careful guidance is provided by the latter.

THE WOODWORKER

Wood being the universal material that it is, the term woodworker is very comprehensive. A woodworker might be a wheelwright, a cabinet maker, a pattern-maker, a shopfitter, a boatbuilder, a wood machinist, a carpenter, or a joiner. The two last named are usually identified with building, and one man may combine both functions, although not necessarily. A properly trained craftsman should, however, be familiar with both sides of the trade and so justify the title of carpenter and joiner.

The *joiner* works in the joiners' shop making doors, windows, cupboards, dressers, stairs, chimney pieces and all the interior fittings for a building, and may occasionally go to the building itself to fix the work.

Being concerned with the finer details of the woodwork for the building, he needs to be a clean, accurate worker and his tool kit must be in keeping. Since the timber he uses is new, the apparatus for keeping tools sharp is always at hand, and if the other conditions are favourable, the joiner is able to take a pride in his "kit"; his saws and planes are usually polished, the latter like a mahogany dining table, by the application of linseed oil and the friction of handling in use. His usual uniform is a white apron—a good indication of the relative cleanness of his job, for apart from dust from sandpapering and an odd splash of glue, the work of the trade is not dirty.

Nowadays machinery can do most of the work; on purely repetitive work this does happen, making the craftsman an assembler of ready-made parts. When work of an individual character is required, the joiner gets an opportunity to exercise his craft skill. Machinery may still be available for preparation of the pieces of material and the routine operations but the setting out, jointing, assembly, and finish will be the care of the craftsman.

It is difficult to generalize about the kind of joinery work which may be expected in a particular type of building firm, but the following gives some indication. A builder in a small community will have a wide variety of jobs to do—repairs and alterations, building a house or a small row of houses, additions to houses or farm buildings and so on. In a large city, and given a large firm, the work will involve town halls, churches and other big contracts, with the probability of high-class joinery work of an expensive character. A medium-size building firm will engage largely in housing estates, small factories and some of the heavy repair jobs. A little outside the sphere of builders' joinery is (a) shopfitting, needing its own technique, and (b) cabinet making which is more concerned with furniture.

It will be clear that the wider the experience which the young joiner can gain, the better equipped he will be to undertake varied work on his own initiative. It is the man who is able to see any kind of job through, who will be chosen to supervise work later on. A capable man is often given the task of supervising the work of several other men and is then known as a charge hand. His job will probably involve setting-out or marking-out work. He may be known as a setter-out or marker-out and may combine both jobs. In a large firm, there will be several of each, and a shop foreman will be in general charge. As the joiners' shop is often the hub of a builders' business, the foreman joiner often eventually becomes works-manager.

The *carpenter* works on the building doing the multitude of jobs needed there. As soon as the site is cleared he will erect temporary huts as offices and stores. The shuttering for concrete foundations and, later, floors and centers for brickwork will keep him occupied. The preparation and maintenance of straight edges, plumb rules and many little

jobs for other crafts will find their way to him. As the building proceeds, his work grows until with the roof he really becomes busy. The wall plates are fixed; then rafters and all the intricate details of hips, valleys and trimmings; and, finally the boarding. The next job will probably be flooring, then fixing door and window frames and rough grounds for the plastering. When this is complete the time has come for stairs, door linings, skirtings, picture rails and architraves. The doors and sashes are hung, some of the ironmongery or furniture fitted, and any interior fitments installed. Such jobs as fencing and fixing gates are among his final tasks; he also dismantles the temporary buildings.

The carpenter's work is so diverse that his tool kit is not usually so carefully maintained as the joiner's. He has to use wood which has been used before and may be coated with gritty material which dulls the sharp edges. He does, however, get a good general knowledge of all the building operations. It is for this reason that, along with the bricklayer, he is often to be found later in life as a general foreman or a clerk of works.

"In WOOD you must work with care, and with respect and love. For wood has soul and spirit, and is not at the mercy of triflers. One slip of your chisel in carelessness or ignorance, one shave too many with your plane, and your work is ruined, fit only for burning."

RICHARD LLEWELLYN

SECTION I

WORKSHOP PRACTICE

WORKSHOP activity in educational courses has developed into a major factor in school life. Its purpose is two-fold—(a) to develop manipulative skill and control in handling a material, whatever the choice and nature of such material; and (b) to approach the constructive task with an orderly mind, appreciating both the “how” and “why” of any process or action, and therefore basing these on reasoned principles.

For the average boy, careful grading of tool exercises is generally necessary and advantageous. The general study of materials and of the principles of construction should accompany the practical approach throughout the course, thus preparing the way and keeping pace with workshop practice. Bench work should not be looked upon as something divorced from theoretical study, but rather be viewed as a concrete approach to the illustration and application of principles which have been established, either by educational and industrial research or by personal and collective experience.

The author has included details of lectures, drawings, and workshop instruction suited to an average course of the type developed in Secondary Technical Schools for Building.

WORKSHOP PROCEDURE

Craftsmanship is a combination of high quality workmanship, and economy of effort and time. The need for good work is obvious but it is also necessary that it shall be done quickly. Speed is attained by working systematically, rather than by using quick movements. It is very spectacular to see bales of shavings coming off the timber like “soldiers’ belts” but if one or two shavings carefully removed will achieve an equally good result, there is no sense in wasting time and effort removing more.

To enable systematic work to be done, method must be carefully learned, just as the sounds represented by letters must be learned before one can read. Therefore, in the early stages of the course, if methods of doing work are committed to memory, succeeding work becomes easier and more pleasurable.

On page 3 (top) is a record sheet with columns for entering items of work, dates of starting and finishing, and marks obtained. This enables us to keep careful record of all we do, including the quality and the time taken. In industry it is usual to keep a somewhat similar record called a "time sheet." This is necessary when wages are paid for hours of work done, as it forms a basis for the bill which the client has to pay for the work. Again, when similar work is to be done, the office staff may have to estimate what it will cost; several firms may be asked for an estimate, the least costly usually gaining the contract. Records are most useful for helping to decide what the cost of similar work is likely to be.

The record sheet should be carefully entered up when starting and finishing a piece of work, and it is desirable to use block capitals and neat figures for all entries.

A more ambitious type of record sheet, which may be useful at a later stage in the course, is shown on page 3 (bottom). Here we can enter total hours taken to complete a piece of work and, by assuming an hourly rate of wages, the cost of the piece of work can be found.

In conjunction with the list of timber used, a final cost price could be obtained; we might even add a fair percentage for profit, thus arriving at the final cost of the work to the client. Then we might ask ourselves the question, "Would we care to pay for the job at that price?"

While economy is of great importance in industry and will depend largely on speed of production, students must bear in mind that their first and main consideration is *quality of craftsmanship*. Care and thought, educationally applied—to any handwork subject—are essential to the successful study of the craft.

When the use of tools has been mastered, so that they can be properly prepared and controlled by the user, then unhurried speed tends to produce clean, smartly finished craft work. Whatever the circumstances the time arrives when rate of production has an important bearing on the work in hand. The man who has trained himself to be sure of his efficiency and who avoids waste of time in unnecessary movements and activities, does quick work of good quality and with least effort.

PLANING THE WOOD TO SIZE

Produce—

(i) *Face Side*; (ii) *Face Edge*; (iii) *Width*; (iv) *Thickness*.

This is the order of procedure for trueing a piece of wood, and getting it to its required dimensions. Remember it, and always work in that order.

A piece of timber will usually have two broad faces and two narrow edges.

Face Side. Begin by choosing the best face and plane it flat using the jack plane, with the least amount of planing. To be sure it is flat test along, across and from corner to corner both ways with a "straight-edge"—usually a steel rule. Mark when true with the tail of the face mark towards the best edge.

Face Edge. With as few shavings as possible plane this edge straight and square to the face side.

Width. Mark the width on the face side with the marking gauge held against the face edge; then plane the rough edge down to the line keeping it square to the face side.

Thickness. On both edges gauge to thickness with the marking gauge held against the face side. Plane to the marks, testing at intervals with the steel rule across the wood.

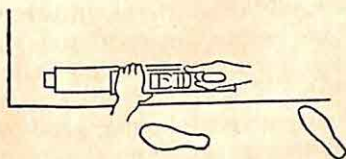
Difficulties. It is necessary that the hands, together with the plane, travel in a straight line. A curving movement causes all manner of troubles, particularly a twisted surface on the wood; this condition is also known as "winding."

Look at the boy planing in Fig. 1 and note the dotted line indicating the slightly upward direction which the plane should take at the conclusion of the stroke. It is quite difficult to do this, for the left hand has to press the plane on to the wood whilst it travels along; the fingers on one side, and thumb on the other, must be gripping the plane to lift at the end of the stroke. Try to make the wood *hollow*; it can be made very slightly so.

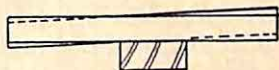
When testing for truth, hold the wood and the straight-edge towards the light; any error is then readily seen. Try across the wood at several points (Fig. 1). To try a surface for winding, hold it at eye level and gaze along and across the surface. Winding "sticks" or "rules" (two parallel strips) (Fig. 1) are a further aid as, when placed across and near the ends of a surface and sighted across their top edges, they magnify any error. They are used while the wood lies on the



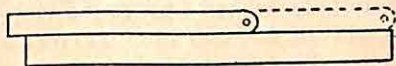
ADOPT A FIRM STANCE WITH FEET ONE PACE APART
THE LEFT HAND PRESSES DOWN AS THE PLANE TRAVELS
ALONG, BUT LIFTS AT THE END OF THE STROKE



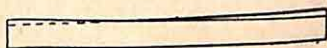
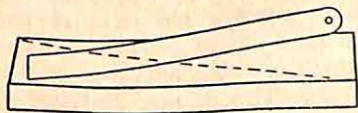
POSITION FOR HANDS & FEET



USE OF WINDING STICKS



TEST THE FACE SIDE IN FOUR DIRECTIONS — ACROSS, ALONG —



A BAD CASE OF 'WINDING'

— & DIAGONALLY BOTH WAYS

FIG. 1. PLANING AND REDUCING MATERIAL

bench, and the operator bends until the eyes are on a level with the top edges.

ORDINARY JOINTS IN JOINERS' WORK

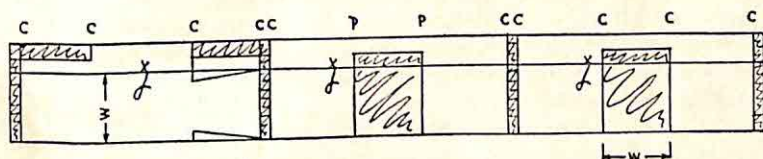
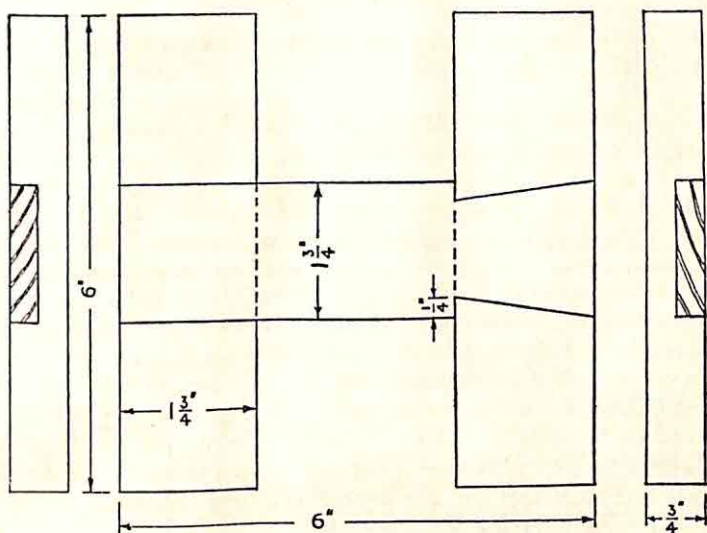
Halving Joints. These are the simplest of the joints used by the carpenter and joiner and are suitable for quick temporary work like stage scenery, exhibition stands, and especially work where plywood is to be fixed to the face of a batten framework (see Fig. 2). The dovetailed halving type of joint occurs in roof work occasionally, e.g. where a collar joins with a rafter. Due to the fact that wood shrinks and swells across the grain, halving joints are liable to work loose, so they are sometimes helped by fixing with screws. Note that a halving joint weakens the wood considerably because half the thickness has to be removed.

MARKING OUT. If the wood has been planed successfully, it will measure $1\frac{3}{4}$ in. $\times$ $\frac{3}{4}$ in.; suppose, however, that you have not been quite successful, and the width is a little under the intended size, then the *actual* width will have to be used when marking out the joints. On the face side (Fig. 2) set off three lengths of 6 in. each with about $\frac{1}{4}$ in. waste between and at the ends. Mark with a try-square and a sharp marking knife all round the wood and scribble on the waste.

Now mark the joint lines on the face edge, and square to the other sides as required. (Note that the marking out diagram in the middle of Fig. 2 has the face side and face edge drawn close together for convenience, instead of showing them separately and apart.)

Remember that any spare or unnecessary knife marks cannot be rubbed out, so be very careful. The socket for the dovetail is marked square across with a pencil line for the time being, for when the dovetail is made, it is necessary to mark round it for the socket so as to obtain an exact fit. The marking gauge is set to exactly half the thickness, and all the gauging is done with the marking gauge held against the face side. Scribble on the waste and notice that when the work is assembled all face marks will be together.

MAKING THE JOINTS (see Fig. 3). The square halving is taken first. Saw along the grain of the cross piece first, then the shoulder, keeping the saw cuts in the waste. Now prepare the socket, making two saw cuts in the waste; then chisel



MARKING OUT THE WOOD

— USING w , THE ACTUAL WIDTH FOR THE JOINTS

C = CUT LINE P = PENCIL LINE

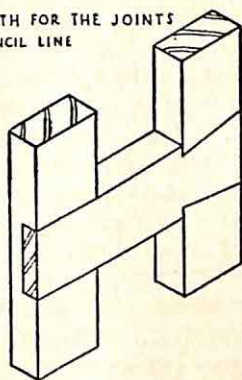
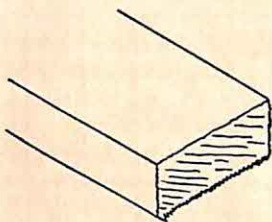
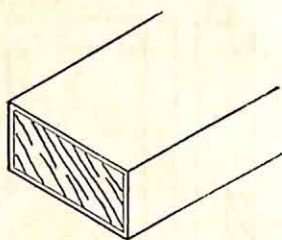


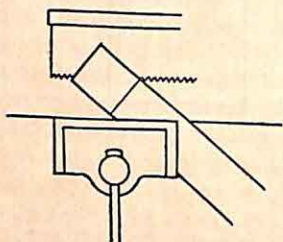
FIG. 2. HALVING JOINTS



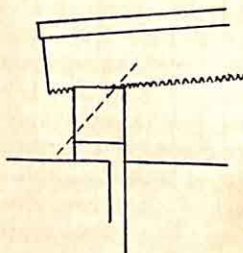
WOOD SAWN ACROSS THE GRAIN
TO A PENCIL LINE
NOTE THE RAGGED EDGES



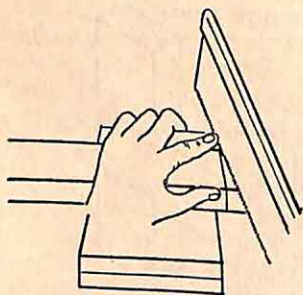
WOOD SAWN TO A CUT LINE
NOTE THE SHARP EDGES, & THAT
HALF THE LINE IS LEFT ON.



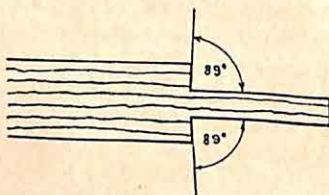
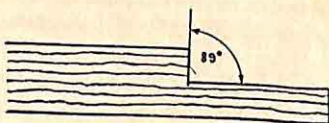
SAW ONE SIDE OF THE JOINT FIRST,



THIS WILL GUIDE THE SAW WHEN
SAWING RIGHT THROUGH



USE THE FOREFINGER TO GUIDE
THE SAW WHEN STARTING SAWCUT.



ANY JOINT HAVING SHOULDERS
MAY BE SAWN SLIGHTLY UNDERCUT
TO ENSURE OUTER EDGE FITTING.

FIG. 3. PRECISION SAWING

from either side *using hand pressure only*. You will find that the wood chisels more smoothly from one side than the other, so finish in that direction.

If the joint is too tight to assemble leave it for the time being and go on with the dovetail halving. The waste on the cross piece is sawn away as before, then a saw cut and careful chiselling removes the small triangular pieces on the sides of the dovetails. Mark around the dovetail for the socket and saw inside those lines, finally chiselling away the waste as before.

Finally, clean up the inside edges with a finely set smoothing plane, assembling, and then cleaning the faces. Note that, in cleaning the edges, the halving joints are made easier fitting. Any waste ends are sawn off and the outer edges cleaned up.

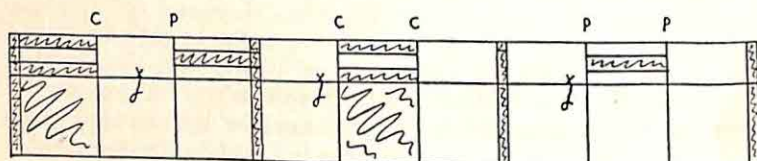
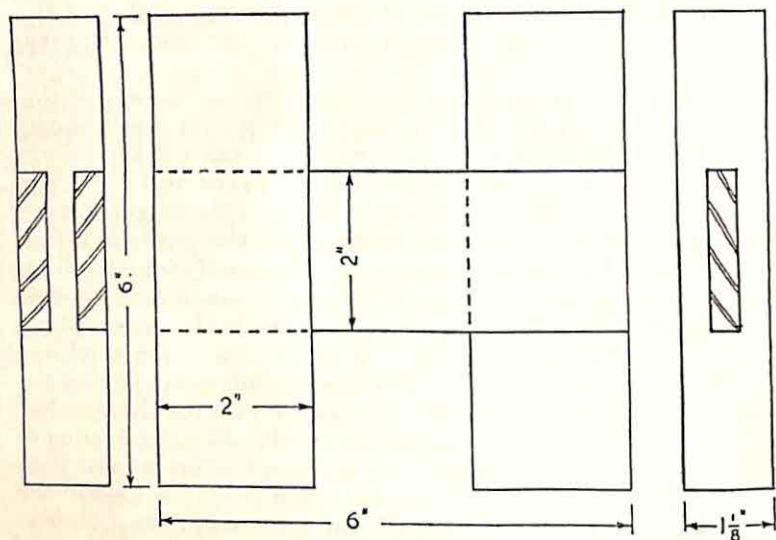
Mortise and Tenon Joint. The mortise and tenon joint is the most widely used of all joints. The type given is the simplest of its kind, and many variations occur. It will be interesting to study some of the constructions in the workshop or classroom to discover how many mortise and tenon joints are used in the making of various items of equipment such as benches, tables and cupboards; also doors, windows and other units of building construction.

So important are mortises and tenons, that certain special machines are used nowadays, one of which does nothing but mortising and the other nothing but tenoning (or similar operations). The huge timbers in houses of bygone ages were constructed with mortises and tenons, and the finest and most delicate cabinet work also used and still uses this joint. It may be concluded therefore that in the study of carpentry and joinery this joint will be met with in different forms; if the correct procedure in its making is mastered at an early stage, succeeding work will be considerably easier.

The Bridle Joint is used where it is undesirable to remove two-thirds of the material on a particular member; the marking out is similar but the scribble showing the waste is in different positions.

MARKING OUT (see Fig. 4). The actual width of the wood is used in marking the joints. Having marked off three pieces 6 in. long, be careful to use the pencil lines (*P*) and the "cut" lines (*C*) in the correct places.

It is advisable to measure accurately the thickness of the mortise chisel to be used, and to set the two marking points



THE MARKING OUT
USE THE ACTUAL WIDTH OF THE MATERIAL
WHEN MARKING THE JOINTS
C = CUT LINE P = PENCIL LINE

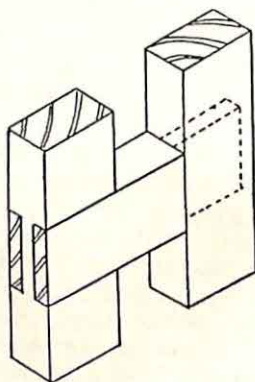


FIG. 4. MORTISE AND TENON, AND BRIDLE JOINTS

of the mortise gauge to this dimension. Then make sure the gauge marks are in the middle of the wood by trying the gauge from both sides. When set right, do all the marking with the gauge held against the face side. By cutting accurately to these lines, the face sides will then be flush when the work is assembled.

MAKING THE JOINTS. The mortise is always formed first and the amount of waste removed by the chisel noted. For example, if both gauge marks have been removed, this must be remembered when sawing the tenon and both marks must be left on. Aim at making the joint fit first time; subsequent easing of either part is undesirable, (a) because it takes extra time and labour, (b) because chiselling of either mortise or tenon is most difficult and the joint may be spoiled. The processes of mortising and paring are given under "Use of Chisels" (page 92).

It is estimated that the tenon has to be about $\frac{1}{100}$ in. *thinner* than the mortise. In soft wood the tenon can actually be a little *wider* (not thicker) than the mortise, the end grain of the mortise being hard enough to enable the tenon to be squeezed together a little. A well-made joint should be hand tight; it should not require knocking together. If it enters about half way, a little pressure may be applied.

WORKSHOP METHOD

Cutting allowances and Order of Procedure. The student will have found that trueing a piece of wood reduces its dimensions appreciably. Therefore, given a required finished size, something must be added to arrive at sawing out or cutting sizes.

As timber is marketed in stock sizes the arrangement usually works the other way, e.g. a piece of 2 in. by 1 in. finishes $1\frac{7}{8}$ in. by $\frac{7}{8}$ in. Whichever way the arrangement works, we must be quite clear when referring to the size of a piece of wood, whether the cutting or the finished size is intended.

The adjoining table shows a method of listing timber in preparation, and the brief summary of operations which follows gives a general guide to which the student may wish to refer quite often during work.

Member	Number	Cutting Size	Finished Size

1. Cut timber from the plank to cutting sizes. On finished sizes—

(a) Allow $\frac{1}{4}$ in. extra for each sawn end ($\frac{1}{2}$ in. on the length).

(b) Allow $\frac{1}{8}$ in. extra for each planed edge ($\frac{1}{4}$ in. on the width).

(c) Allow $\frac{1}{16}$ in. extra for each planed face ($\frac{1}{8}$ in. on the thickness).

2. (a) Plane the best face perfectly flat and mark with face side mark.

(b) Plane the best edge square to the face side and straight and mark with face edge mark.

(c) Gauge slightly full of the finished width, and plane the back edge square to the face side.

(d) Gauge slightly full of the finished thickness on both edges, and plane off the surplus stuff.

3. *Setting Out*

(a) Mark all lengths using cut lines for saw cuts, and pencil for any other work.

(b) Mark rebates, grooves or halvings with a marking gauge; chamfers with a pencil gauge; mortise and tenons with a mortise gauge.

(c) Scribble on the waste.

4. *Framing*

(a) Cut mortises.

(b) Saw tenons along the grain only.

(c) Form rebates, grooves, and mouldings.

(d) Cut shoulders, haunchings, and wedges.

(e) Fit together, numbering the joints as fitted.

5. *Assembling*

(a) Clean all inside faces.

(b) Glue and fix.

(c) Clean off.

Haunched Mortise and Tenon Joint. This joint is used for the mortise and tenon at the external angle of a door or other frame, when it is desired to wedge the joint to gain a firm hold and make a rigid corner. In Fig. 5 it is applied to the corner of

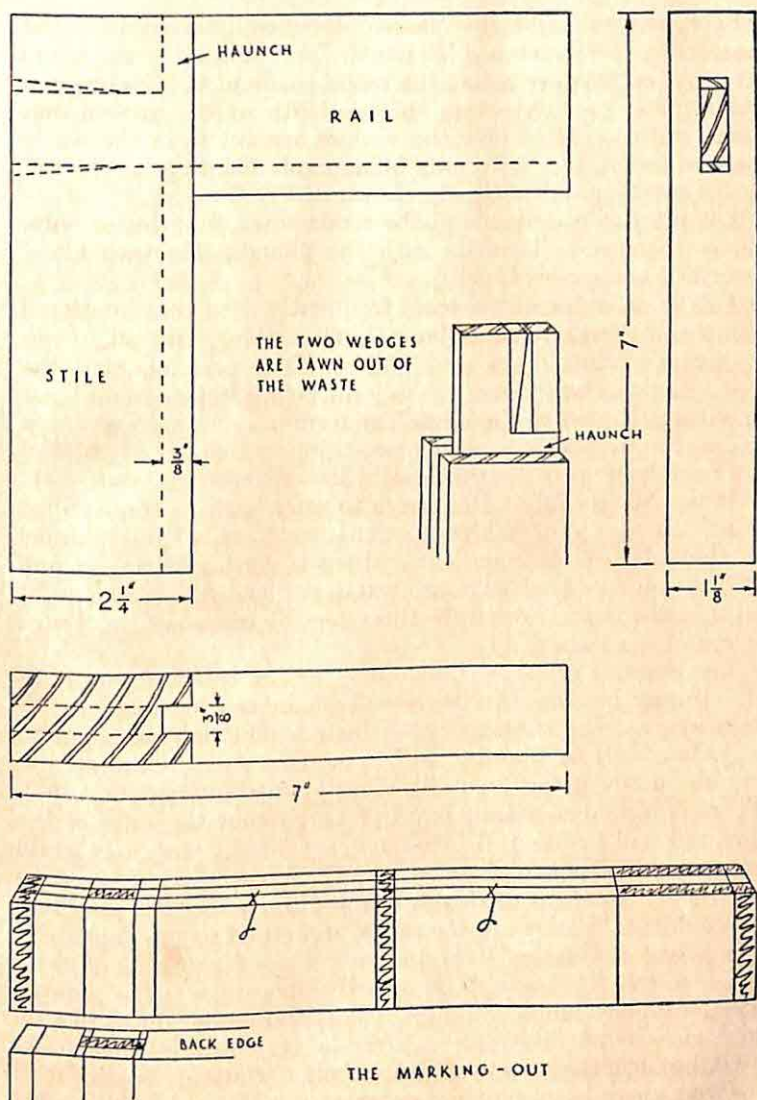


FIG. 5. HAUNCHED MORTISE AND TENON JOINT

a door, the rail and stile being ploughed (grooved) on the inner edge to receive a $\frac{3}{8}$ in. panel. The haunch is the short piece left on when reducing the tenon to about half its original width. The haunch enters to the depth of the groove and exactly fills it. Note how the wedges are cut from the waste piece of tenon, the down cuts being made before removal.

The marking out is clearly shown in Fig. 5.

The mortise is driven and the tenon sawn, lengthwise only, before the groove is made with the plough, (illustrated and described on pages 111-113).

This joint is one of the most frequently used constructional joints and the principle of haunching is widely applied.

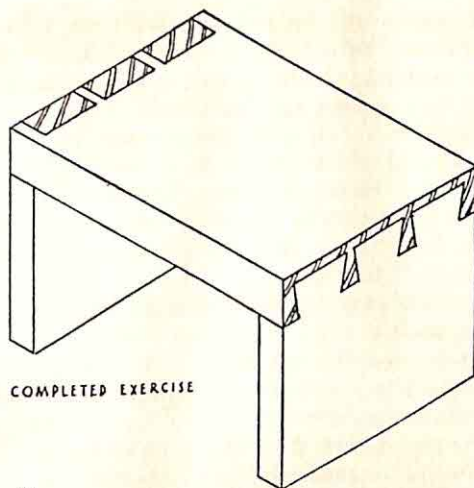
Dovetail Joints (Figs. 6, 7 and 8). It is probable that the name dovetail was given to the joint owing to its resemblance in parts to the tail of the bird. The term has become a common expression in speech, meaning two things which exactly fit and are complementary; a good point to remember in your work.

It may be useful at this stage to refer back to the combed joint. In this joint the component parts are set out parallel to the sides of the members; there is consequently no pull on the joint as the parts are put together. A dovetail joint on the other hand does have this effect by reason of the wedge shape of the tails.

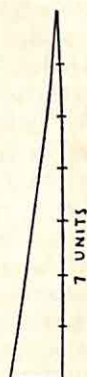
The amount of slope (from lines parallel to the edge of the wood) may be stated in degrees of inclination or as a road or railway gradient is stated. For instance 14° is equivalent to a gradient of 1 in 4, and 6° to 1 in 9. These are maximum and minimum bevels for dovetails, a happy medium is 8° or 1 in 7. There is a danger with a bevel of 1 in 4 that the sides of the dovetail will bruise and break off, because of the short grain at each side.

Now as to width of dovetail holes and pins. On machine-made dovetails they are the same, and equal to the depth. So the joints are designed around a series of squares, of sides equal to the thickness. The only disadvantage is the appearance. When cabinet-makers use hand-made dovetails on high-class work, the pins are made very small. This looks well, but has the disadvantage of being relatively weak.

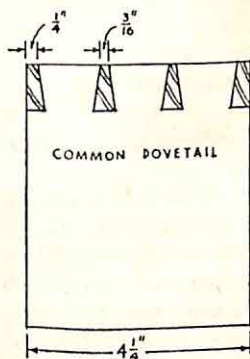
Somewhere between the two extremes, depending upon the purpose of the joint and balancing strength with appearance, we must find a happy mean. It is recommended for joinery



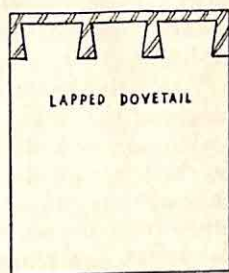
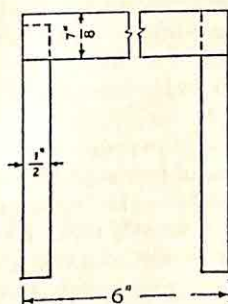
THE COMPLETED EXERCISE



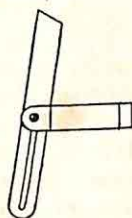
1 UNIT
BEVEL FOR DOVETAILS



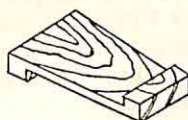
COMMON DOVETAIL



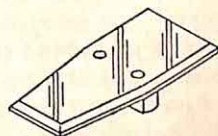
LAPPED DOVETAIL



JOINERS' BEVEL



HARDWOOD TEMPLLET



METAL SQUARE & BEVEL

ALTERNATIVE AIDS FOR MARKING DOVETAILS

FIG. 6. COMMON AND LAP DOVETAILS

work that the middle of the pins should be a minimum of half the thickness of the thinner member. When considering the number and width of the dovetails, bear in mind that wide ones may not suffice to keep the joint tight if the wood warps, whereas narrow ones mean a bigger number and therefore extra labour. A good general guide is to make the middle of the dovetail (the material between the holes) a minimum width equal to the thickness of the thicker piece. The face lap on the lapped joint should never be less than $\frac{1}{8}$ in.; even this will be quite difficult to achieve in practice. Many beginners (not to mention others) have split the front away when cleaning out the sockets.

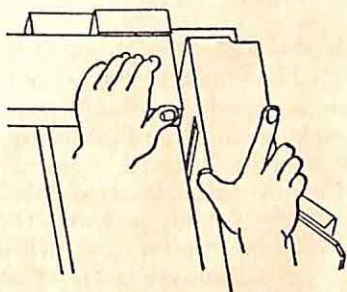
Corner joints in general are described on page 158. The most important to the joiner are the common and lap dovetails, used for hand-made drawers.

COMMON DOVETAIL (Figs. 6 and 7). The ends of both pieces to be jointed are sawn square to a cut line and then planed on the shooting board. It is advisable to pare off a small corner to avoid splitting the edge away when planing end grain. The setting out and working of the joint are illustrated in Figs. 7 and 8.

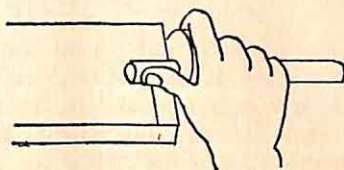
To mark the depth of the joint on both pieces use a sharp marking gauge or finely set cutting gauge; alternatively, a try-square and marking knife may be used. The dovetails are marked in pencil by using one of the implements shown at the bottom of Fig. 6, and the sloping sides are then sawn. The other piece is now set up in the vice at the same height above the bench as a plane or mallet and the piece with the dovetails supported and held firmly as shown while marking through with the saw.

The pins can now be sawn, leaving the saw impressions on them. To remove the waste on both pieces chop out with mallet and chisel from either side; except when dealing with pieces, which are sawn. Some difficulty in chopping out often arises from the structure of the wood; the fibres part behind the chisel leaving a gap in the end grain. A good way of overcoming this trouble is to remove most of the waste with a coping saw (a near relative of the fretsaw) and finish with a sharp chisel, using hand pressure only.

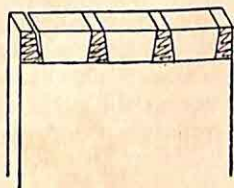
LAPPED DOVETAIL (Figs. 6 and 8). Set the gauge to the length of the dovetails and gauge (a) from the end of the



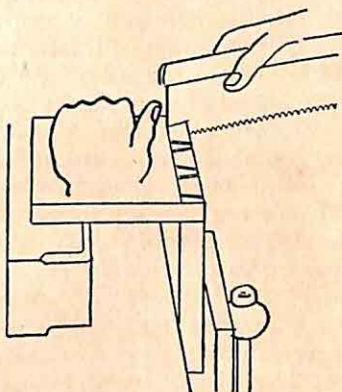
SHOOT THE ENDS SQUARE
USING SHOOTING BOARD & TRY PLANE



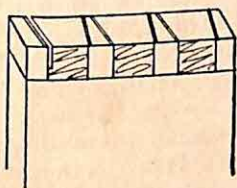
GAUGE THE END OF EACH PIECE
WITH GAUGE SET TO THICKNESS
OF THE OTHER PIECE



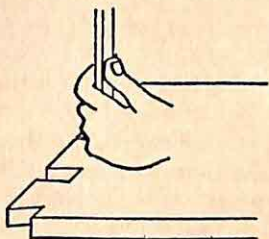
SAW THE DOVETAILS, KEEPING
SAWCUTS IN THE WASTE



SETTING THE PIECES FIRMLY, MARK
THROUGH WITH THE SAW



SAW THE PINS, LEAVING THE
IMPRESSIONS MADE BY THE SAW



REMOVE THE WASTE BY
CHISELLING FROM BOTH SIDES

FIG. 7. SETTING-OUT AND MAKING A COMMON DOVETAIL JOINT

thinner piece and (b) on the end of the thicker piece. Also gauge the depth on the thick piece. The pins are now set out, sawn as far as possible, then the waste chopped out while resting flat on the bench. The sockets must be finished off with a small chisel while the piece is held in the vice.

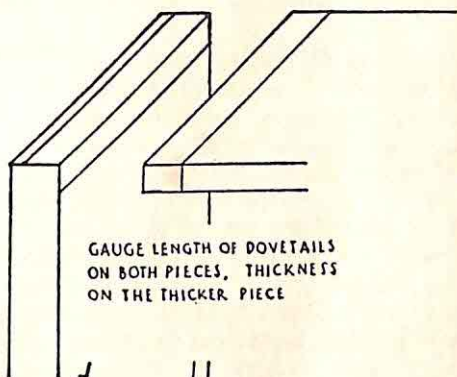
The dovetails are marked from the pins with a finely pointed pencil. When removing the waste be careful to leave the pencil marks on the dovetails. Clean the inside faces with a finely set smoothing plane, bearing in mind that the pins will be made easier fitting by the amount removed. Assemble the joints and smooth up, planing from end grain to long grain to avoid splitting away on the end.

It will be noted that a different method has been described for each type of dovetail joint. The two methods may be briefly described as saw marking and pencil marking respectively. Either method may be adopted for either joint. Saw marking is probably quicker and pencil marking more suitable for beginners, because unpractised hands find a saw rather unwieldy for use as a marker, particularly as the other hand must hold the material steady. On bigger work a cramp may be employed to perform the latter function.

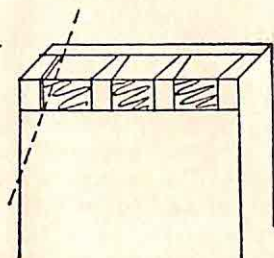
FITTINGS AND FURNITURE

Tee-square (for quarter-imperial sheet). Imperial size drawing paper is 30 in. by 22 in. Schools usually use half or quarter Imperial sheets for drawing, 22 in. by 15 in. and 15 in. by 11 in. respectively. Since homework sheets are most often the smallest size, it will be useful to have a tee-square of suitable size for use at home. The instrument consists of a stock and a blade. Taking the bigger dimension (15 in.) and allowing about 1 in. for margin on the drawing board, the inside length of the blade becomes 16 in.; an allowance of 2 in. for fixing to the stock brings it to 18 in. A suitable length of stock for this tee-square will be 8 in. (See Fig. 9.)

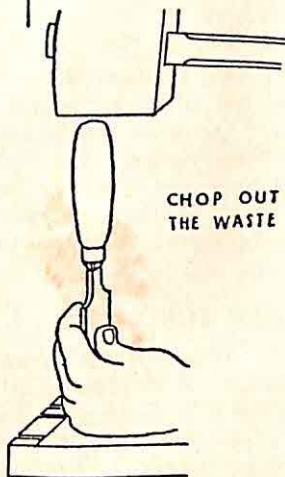
There are several timbers in common use for tee-squares, of which pearwood is probably the best. When mahogany is used an edging of harder wood is advisable. For our purpose red or white beech is a good choice provided it is well seasoned. As it is hard, it is desirable to have the flat surfaces machine-planed. It remains to plane the edges true on the shooting board, using a try plane.



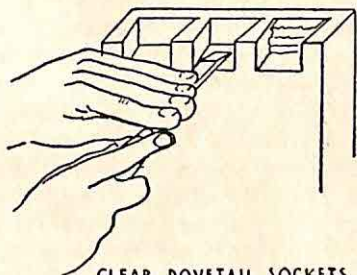
GAUGE LENGTH OF DOVETAILS
ON BOTH PIECES, THICKNESS
ON THE THICKER PIECE



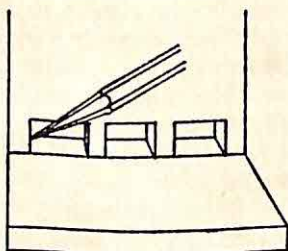
SAW AS MUCH OF THE
PINS AS POSSIBLE



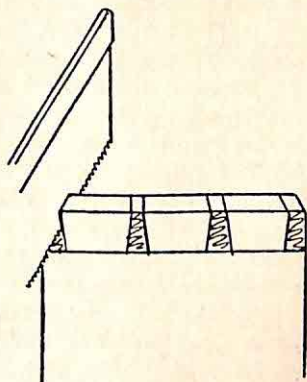
CHOP OUT
THE WASTE



CLEAR DOVETAIL SOCKETS
WITH A SMALL CHISEL



MARK THE DOVETAILS WITH
A FINELY POINTED PENCIL



SAW THE DOVETAILS, LEAVING
THE PENCIL MARKS ON THEM

FIG. 8. SETTING-OUT AND MAKING A LAP DOVETAIL JOINT

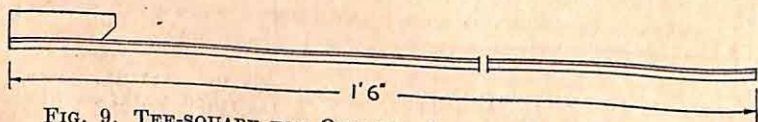
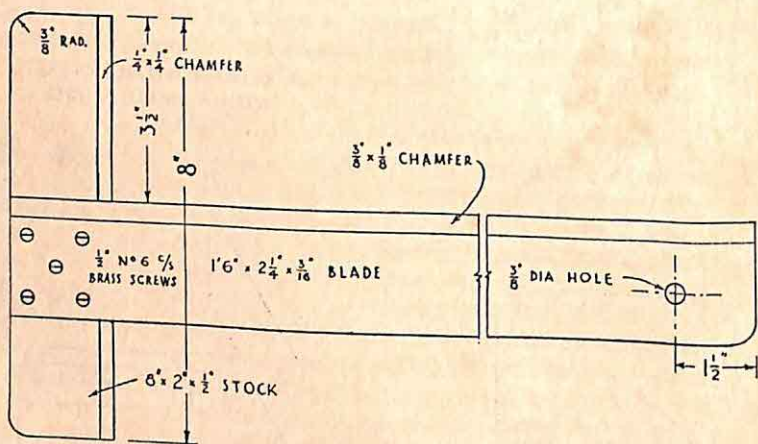
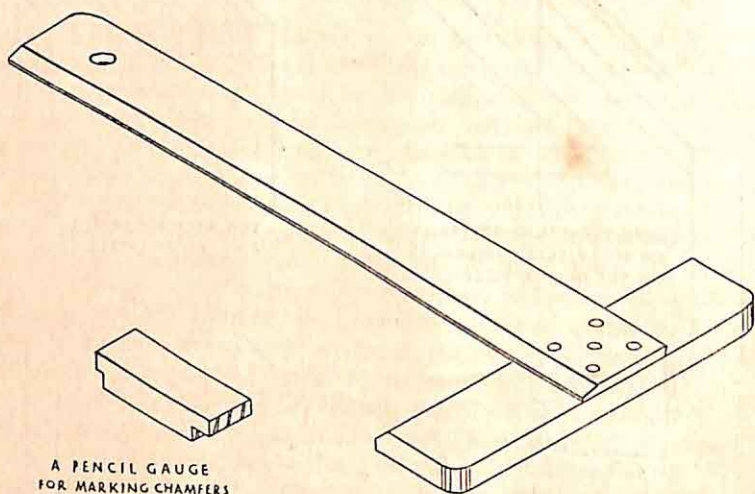


FIG. 9. TEE-SQUARE FOR QUARTER IMPERIAL DRAWING BOARD

The pieces should be sawn to length and the ends planed on the shooting board, care being taken to chisel off a small corner to prevent splitting. Prepare the pencil gauge for the chamfers; then mark the pieces and plane them in the vice. The thin blade will need a thick piece of wood behind to prevent it bending.

Set out the holes carefully and drill those for the screws to a size that allows the screw-shank an easy fit; they should be counter-sunk so that the screw heads will turn down flush with the surface of the blade.

Glasspaper the flat surfaces, and assemble the two parts as near square as possible, checking after each screw has been put in. (It is not essential that the parts are dead square.) Try to have the slots all in one direction. The rounded corners are formed by paring with a chisel and glasspapering.

The tee-square should be french-polished to prevent pencil lead and other dirt becoming ingrained, as this makes drawing paper dirty.

Drawing Board. A drawing board can be made by joining boards edgewise and fixing battens on the back. It is much easier, however, to purchase a piece of $\frac{1}{2}$ in. blockboard or plywood and plane the edges. The cost of either is negligible compared with the article bought in a shop, and they are just as effective.

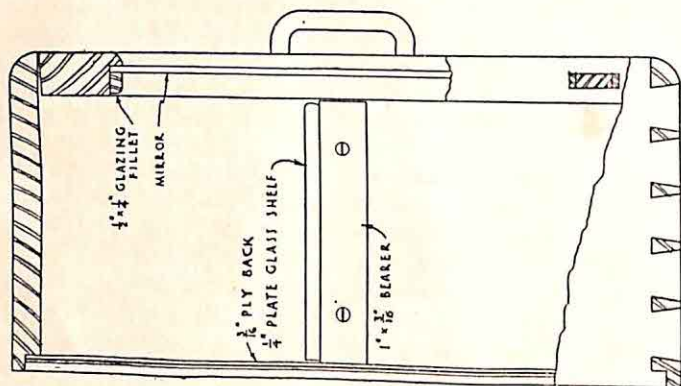
Transparent Tee-square. One day it may be worth while to obtain a piece of "Perspex," and make a tee-square which is transparent like many set-squares. "Perspex" may be worked with ordinary woodworking tools, but they must be nicely sharpened and skilfully used.

Household Cabinet (Fig. 10). This provides an exercise on a small scale of many of the processes of joiners' work. The door is glazed with a piece of thin plate mirror; the frame is rebated for glass and is quadrant moulded on the solid, necessitating a mitred joint. Loose beads are mitred and nailed to retain the glass.

The body of the cabinet is dovetailed at the angles (Fig. 11) and is rebated for the plywood back panel. Bearers are screwed inside to support the shelf and to form a stop for the door. Many of the incidentals—hinges, handle and ball catch—provide an exercise in furniture fitting. The hinges and possibly the handle can be purchased of course, but a variety

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OUTSIDE SIZES
 $1'2" \times 10' \times 6\frac{1}{4}"$
 DOOR $1'1" \times 9' \times \frac{15}{16}"$

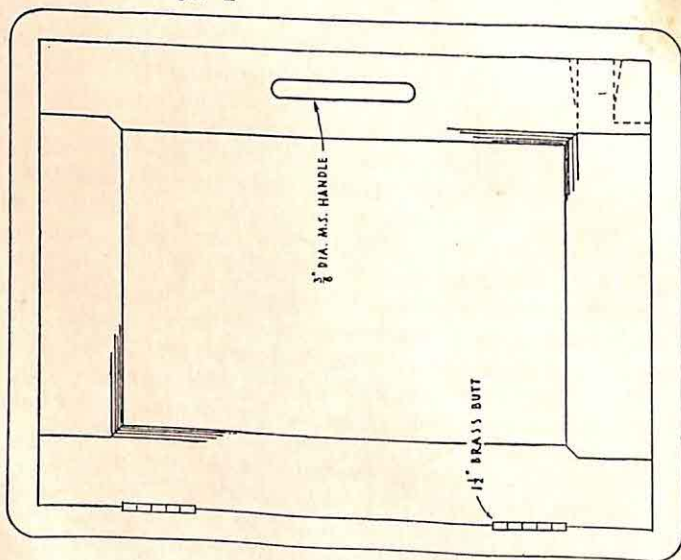


FIG. 10. HOUSEHOLD CABINET

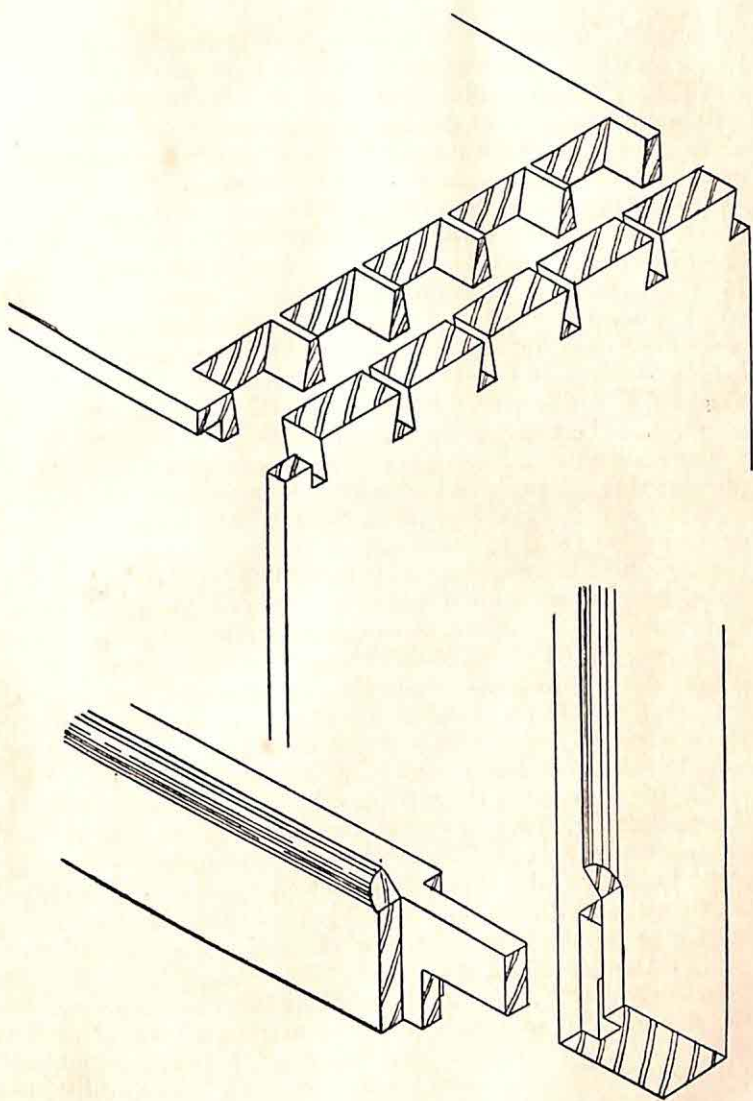


FIG. 11. JOINTS FOR HOUSEHOLD CABINET

of suitable handles may be made in the woodwork shop or the metalwork shop. The mirror is best bought cut to size; but this and the plate glass shelf may be cut in the woodwork shop with a steel wheel type of glasscutter, which is quite inexpensive. The round front edge of the shelf can be formed with a coarse oilstone and finished with a fine stone.

Everything on the cabinet is symmetrical about a horizontal centre line. Thus by turning it upside down the door opens the opposite way, making the cabinet adaptable for any position. It is best finished with a good quality enamel or varnish paint, and if possible done under the watchful eye of the teacher of painting and decorating. White or cream for the cabinet with a contrasting colour like red or black for the handle looks effective. When fixing the thin mirror panel it may be bedded in "back putty." A thick mirror with square edges would reflect the surface of the rebate; to prevent this the surfaces are painted black.

It is usual workshop practice to make the carcass (in this case, the body of the cabinet) first. But it is proposed to make the door first in case the fitting in making the joints takes a little more wood than originally bargained for; a suitable allowance is then made when setting out the cabinet carcass.

The working drawing shows rounded corners; this feature is optional and in any case should not be carried out until all the other work is finished. Where it is to be done the outside pin of the dovetail joint should be wide enough on the outer edge to take the whole of the rounded angle.

MAKING THE DOOR (Figs. 12 and 13). *Marking Out.* When the material has been planed to dimension the stiles and rails are marked in pairs. This is done by placing face sides and edges together and gripping in the vice. The length is marked on, then the width set back from both ends, another line being marked $\frac{1}{4}$ in. short to allow for the rebate, which removes $\frac{1}{4}$ in. off the width of the tenon.

In the case of the tenons the marking last mentioned will be the shoulder line, and it is therefore marked all round with a cut line. The mortises on the stiles are half the remaining width ($1\frac{1}{2}$ in.). Square these marks over and allow an additional $\frac{1}{8}$ in. for wedging on either side of the mortise on the back edge. Next gauge the joints with the mortise gauge and scribble on the waste.

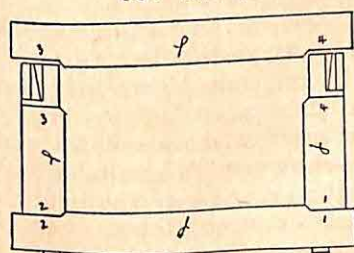
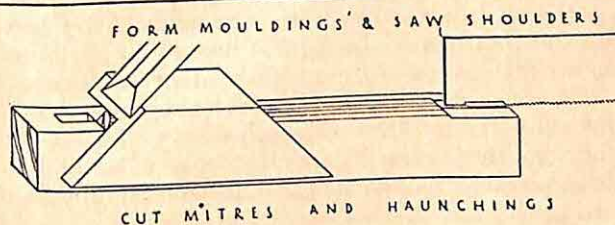
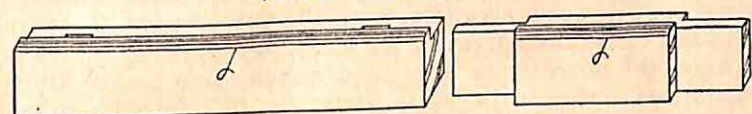
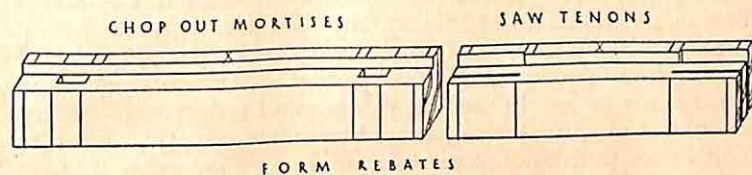
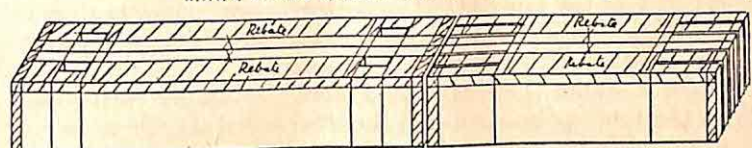
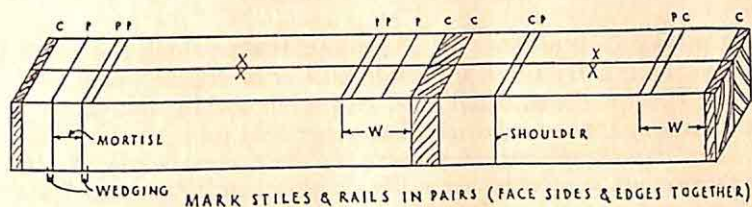


FIG. 12. MARKING OUT AND WORKING DOOR FOR HOUSEHOLD CABINET

Cutting. Cut mortises first, then saw tenons along the grain. Form the rebates by using a side fillister or rebate plane, and work the quadrant moulding with a smoothing plane or a hollow plane, finishing with glasspaper held on a block.

The haunchings are formed $\frac{1}{4}$ in. deep, and some of the waste removed next to the mitres with a saw, finishing with a chisel and mitre templet. The latter operation is best performed with mitre templet and work gripped firmly together in the vice.

When marking the tenons and wedges, number each joint. Then the tenons are sawn and the door fitted together.

Glueing Up (Fig. 13). Have glue, wedges, a hammer and a thin pointed rod in readiness, and set the cramps out of winding. Thin slivers of wood may be used to bring the cramps to a level. Glue the joints, and set the door square in the cramps before tightening. The wood rod is used to test the diagonals and if necessary the cramps are moved very slightly to pull the longer diagonal in. Glue the wedges, insert and commence driving with the outer wedge, tapping it to bring the mitres tight. Then continue tapping the wedges in turn, the outer one a little harder than the inner, to keep the mitre close.

Cleaning Up. It is advisable to leave the glue to dry before cleaning up, but not essential. A little linseed oil on the sole of the plane will prevent clogging if the door is cleaned up before the glue is quite hard. Four blocks, each held in place by a small screw, will keep the job steady while cleaning up with the smoothing plane. Be sure to plane flat and take off as little as possible. Glasspaper should be used only to put a final finish to the work.

HINGING AND HANGING THE DOOR. The edges of the door must be planed carefully, first to make the door a tight fit in the opening in which it is to be hung, and then a little more to give a small space all round. This space is often referred to as a sixpenny joint, because it needs to be about the same thickness as a sixpence. (A "penny joint" is suitable for a larger door, like a room door.) If no space were allowed (even if no expansion due to moisture occurred) the door would stick in the opening after painting. For polished work, a smaller space is permissible.

It is good practice to plane the edges slightly underset;

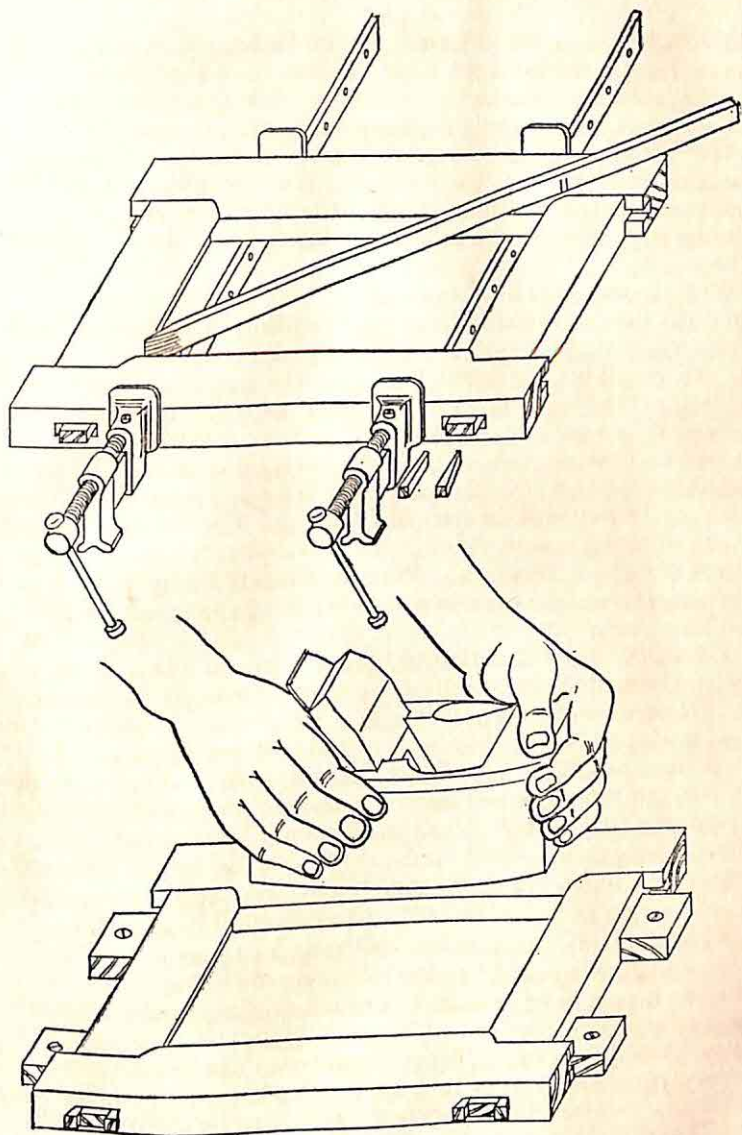


FIG. 13. CRAMPING, SQUARING AND FINISHING DOOR FOR HOUSEHOLD CABINET

that is, less than a right angle to the face. And it is essential to do this on the edge which is farthest from the hinges.

Fig. 14 should make the reason for this quite clear. It will be noted that the whole door swings through an arc of which the centre is the hinge pin. Therefore the distance from the back edge of the door to the centre must be the same as that on the front. The diagram shows a very tiny door, and this exaggerates the angle. As the width of the door increases the underset diminishes, but even quite large doors will need a slightly underset shutting edge.

With the door held in the vice, the position of the hinges on the edge is marked, preferably with a sharp penknife, because a marking knife is rather thick for the purpose. Then with two marking gauges (or one, plus the improvised gauge in Fig. 14) the width and depth of the housing to receive the hinge can be marked. The improvised hinge gauge—a piece of hardwood and a No. 6 iron screw—is a very useful implement. It may be made in a variety of sizes and labelled for different sizes of hinge, and can also be used to make small bead mouldings, the slot acting as a cutter; it is highly efficient if the top of the screw is filed to provide sharp edges.

The waste can now be removed, either with two saw cuts and a little careful chiselling, or by deepening the knife cuts with the knife or a chisel.

When starting the screw holes, make them towards the back of the hole; this ensures that the hinge is pulled tightly into its housing. Finally put the door in the opening, mark hinge positions thereon and remove the waste.

Larger Cabinet with Drawer. The cabinet shown in Fig. 15 involves considerably more work. There are four main parts: the body of the cabinet, the front frame, the door and the drawer.

The cabinet is dovetailed at the top corners, and the face framing glued on and fixed with panel pins or brads, with glue-blocks inside. The bottom has rounded edges at the front and sides, and is nailed on. The shelf, grooved into the sides, forms the door stop. The door members have a square rebated section necessitating a long and short shoulder joint. Loose fillets are mitred and pinned in to retain the mirror panel.

The drawer is lap dovetailed at the front, and common dovetailed at the back. As the back is narrower than the

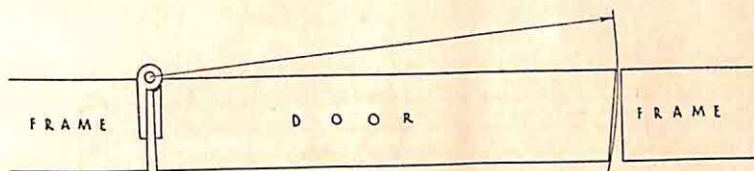
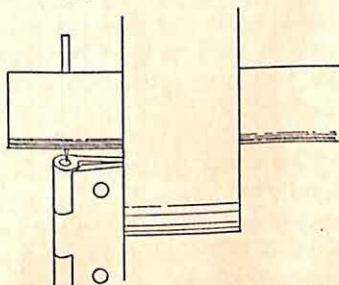
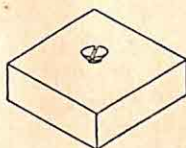


DIAGRAM TO SHOW THE NEED FOR UNDERSET EDGE



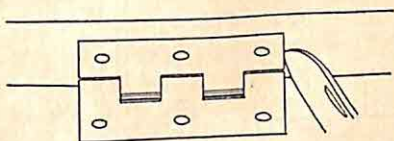
SET A MARKING GAUGE SLIGHTLY SHORT OF THE KNUCKLE CENTRE



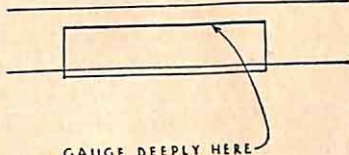
A SIMPLE BUTT GAUGE



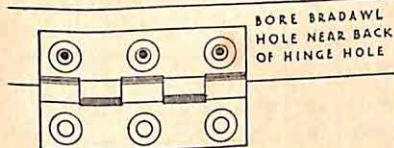
SET THE BUTT GAUGE TO LESS THAN HALF THICKNESS OF BUTT



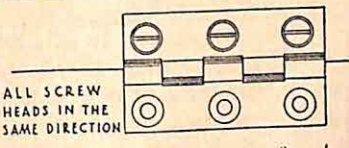
MARK THE LENGTH WITH A SHARP KNIFE



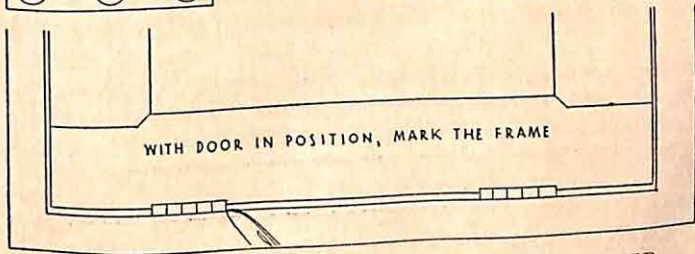
GAUGE DEEPLY HERE



BORE BRADAWL HOLE NEAR BACK OF HINGE HOLE

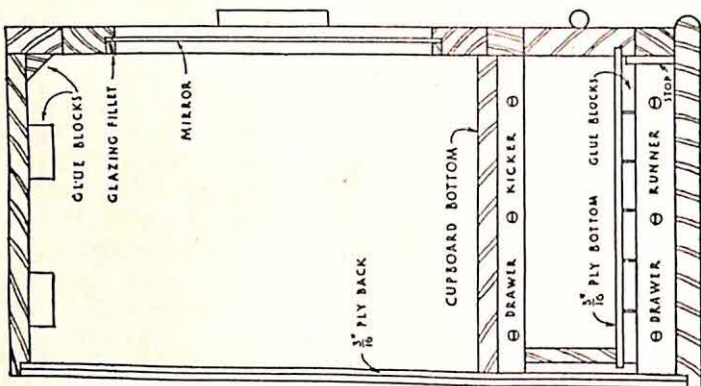


ALL SCREW HEADS IN THE SAME DIRECTION



WITH DOOR IN POSITION, MARK THE FRAME

FIG. 14. FITTING AND HANGING DOOR FOR HOUSEHOLD CABINET



OVER-ALL SIZES
 $1'6\frac{1}{2}" \times 1'0" \times 9\frac{1}{8}"$
 CUP'D DOOR $11\frac{1}{2}" \times 9"$
 DRAWER $9" \times 9" \times 3"$

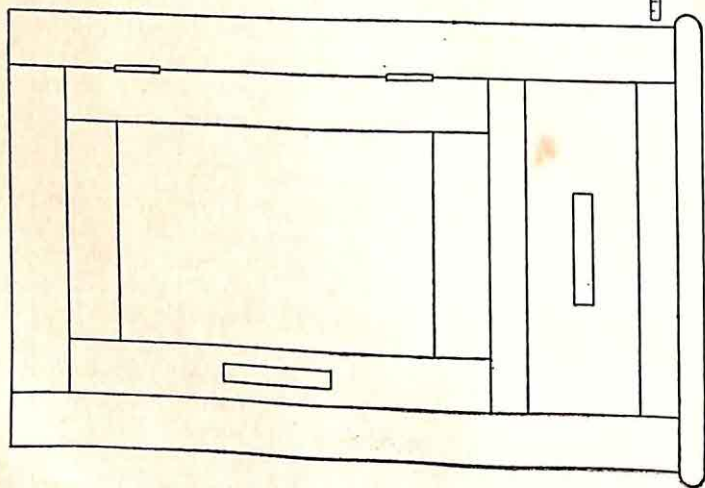
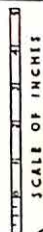


FIG. 15. ALTERNATIVE CABINET, WITH DRAWER

sides and front by the amount of the ply bottom and glue-block runners, the lowest pin has one square edge.

Drawer kickers and runners should be of hardwood and screwed to the side perfectly square and parallel. The drawer stops may be two pieces of plywood screwed to the back of the face framing. Handles for drawer and door may be made from short lengths of $\frac{1}{2}$ in. or $\frac{5}{8}$ in. dowel, each fixed with two screws.

The cabinet is intended to be made from material of 9 in. by $\frac{5}{8}$ in. nominal size finishing about $8\frac{1}{2}$ in. by $\frac{1}{2}$ in. The face framing $\frac{3}{4}$ in. and the projection of the base $\frac{3}{8}$ in. thick make up the $9\frac{5}{8}$ in. dimension. The face frame is made 1 ft 6 in. long (with stump tenons). When the $\frac{5}{8}$ in. bottom is fixed, the overall length is 1 ft $6\frac{5}{8}$ in. The drawer is made a little short, so that it does not tend to push the back off, and stops keep it flush with the face when pushed in.

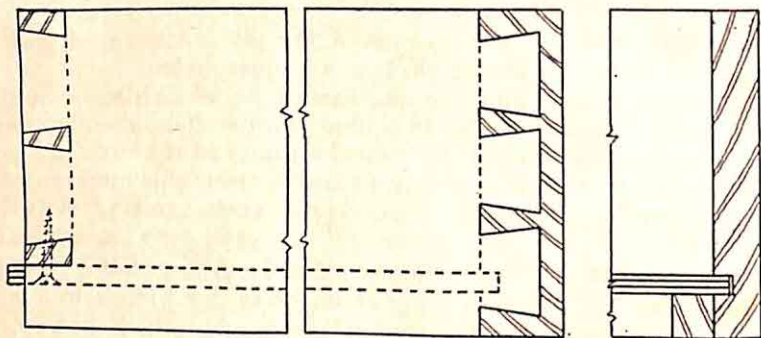
The ply back is fixed last, with pins or small French wire nails.

DRAWER CONSTRUCTION (Fig. 16). The first job is to shoot the ends of the front, back and sides. If the body (or carcass) is already made, the front drawer may be made a tight fit in the opening which it is to fill, the drawer back being made $\frac{1}{16}$ in. shorter, to save planing when fitting the finished drawer. The sides are short of the full length by the amount of the lap on the lapped dovetails. The drawer should be shorter than the full length of the carcass to avoid contact with the back of the carcass.

Next, decide which method of dovetailing to use, pencil or saw marking, and mark out the pins for pencil, or the dovetails for saw marking. The latter method saves time, for a pair of sides (with face sides and edges together) are put in the vice, marked and sawn as a pair.

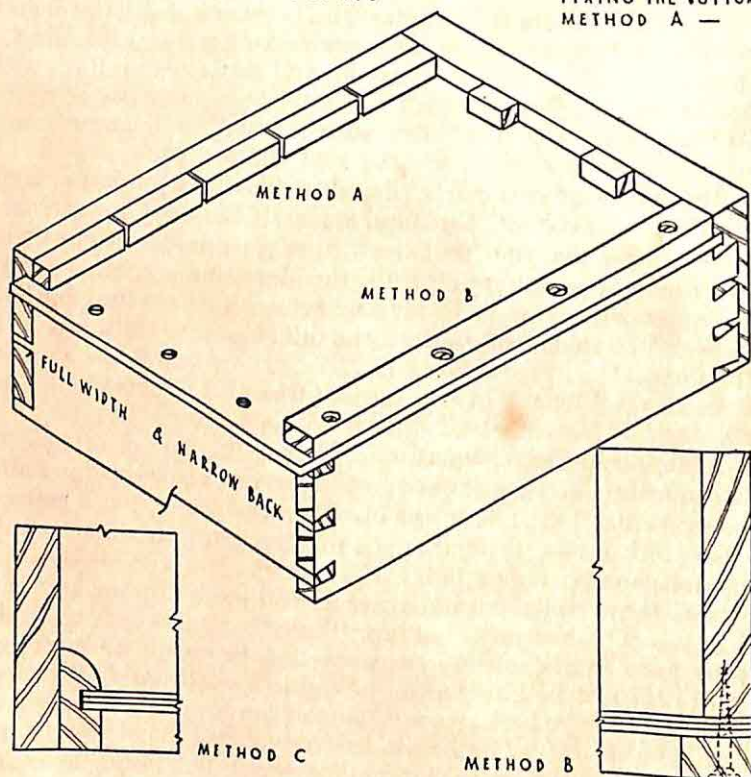
Note that the back is narrower than the sides by the amount that the ply bottom is set up. Sometimes the drawer back is set down from the top edges as well, with possibly a rounded edge; this allows free escape of air to and from the drawer and makes for easy and unobstructed movement.

Method A: It is preferable to groove the sides and front after the dovetailing is finished. Do not push the dovetail joints right home when trying the joints together. When cleaning up the inside faces, before glueing up, bear in mind



DETAIL OF DOVETAIL JOINTS

FIXING THE BOTTOM
METHOD A —



METHOD C

METHOD B

FIG. 16. DRAWER CONSTRUCTION

that the joints will be made easier fitting (the wide part of the pins are being planed off) and take off very little.

The glueing up must be done quickly if the glue is not to chill in the process, and it is advisable to lay the pieces so that they are in the correct order for assembly, glueing the front and back, then the sides held back to back. A few sharp taps with a hammer (using an odd piece of wood to save bruising) should suffice to send the joints home, and the drawer should be laid aside, making sure it is square by checking the lengths of the diagonals.

The ply bottom is slid in when the glue is dry and two or three screws put in the back, again checking for squareness. The hardwood blocks are made in a length, sawn into short pieces and each one glued and rubbed to exclude surplus glue.

Method B: This construction saves work and material and is very effective. The sides are not weakened by grooving. If hardwood runners are used and the screws well countersunk, no harm is done to planes in the fitting process. This method is largely used in shop-fitting.

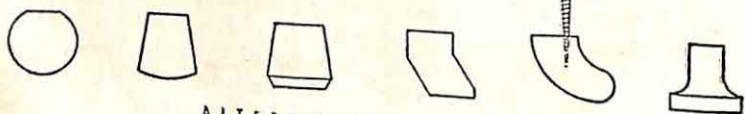
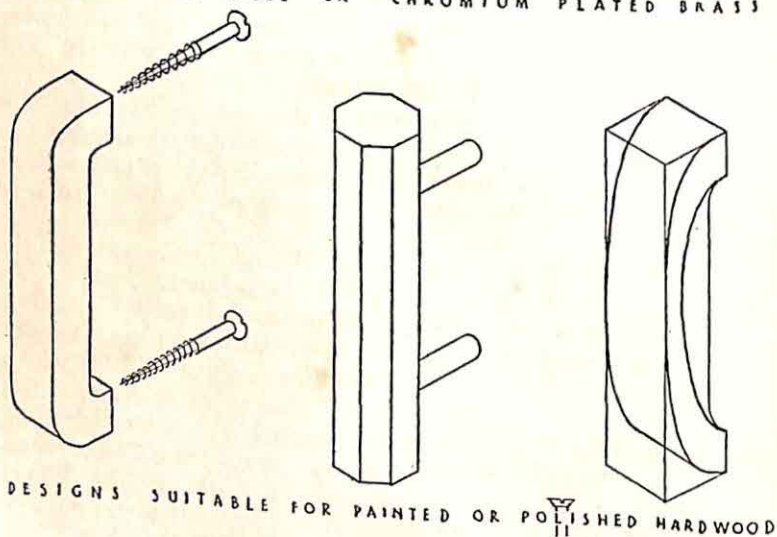
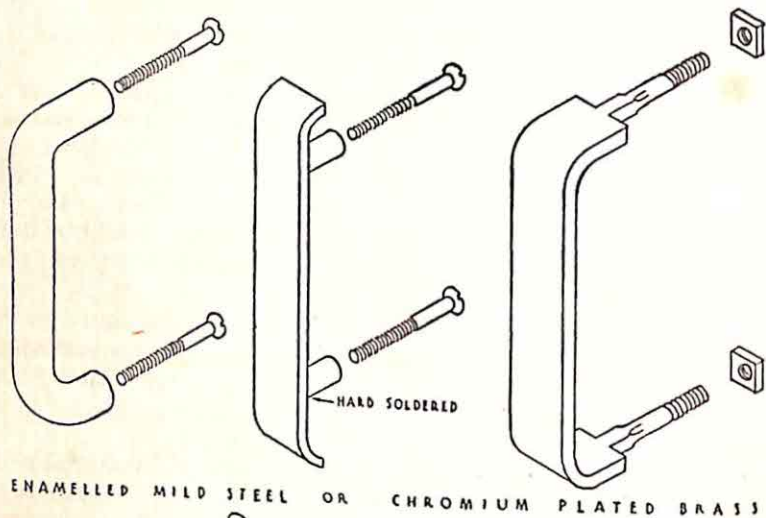
Method C is often employed in fine cabinet making. The sides being too thin for either of the last two methods, separate slips are mitred in on the front and sides, glued and pinned. This is probably the easiest and most adaptable method of the three.

Fig. 17 shows a series of metal and hardwood handles suitable for the door and drawer of the cabinet.

Half-glazed Door. JOINT OF MIDDLE RAIL AND GUNSTOCK STILE. Fig. 18, page 35 shows the elevation and sections of a half-glazed kitchen door associated in one framed unit with a side window and fanlights. (Half-glazing in this connection means glazing above the middle rail.) The entire drawing should be carefully examined before commencing this exercise.

A detail of the joint between the stile and the middle rail is given in Fig. 18, the upper portion of the stile being reduced in width so as to give more glazing area and therefore admit more light. The strong lower portion of the stile, jointed to wide middle and bottom rails, gives rigidity to the door.

The joint shown in Fig. 18 should be made to not less than half scale; or, where time and circumstances allow, the entire door might be made. Note the arrangement of the joint at



ALTERNATIVE SECTIONS
FIG. 17. DOOR AND DRAWER HANDLES

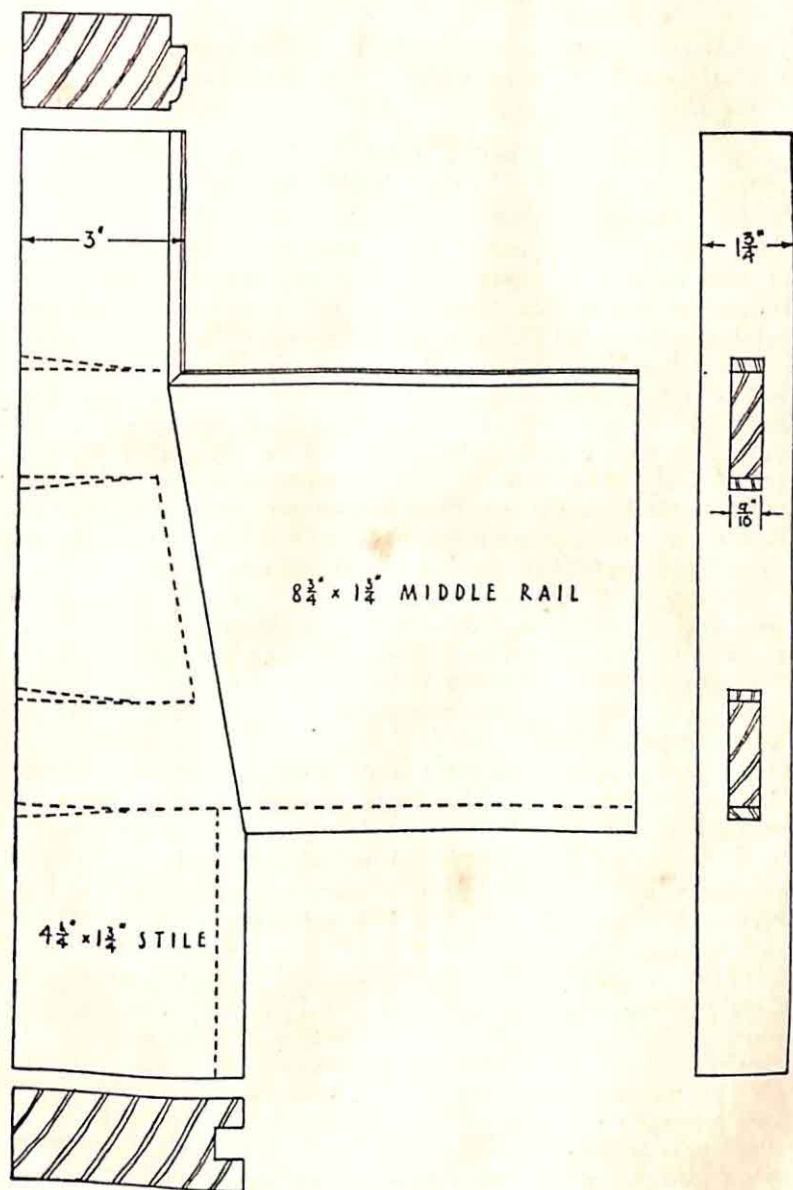


FIG. 18. JOINT FOR DIMINISHED (GUN STOCK) STILE AND RAIL

the intersection of the moulded edges. The end of the rail is scribed—cut to fit over a short continuation of the moulded portion.

SETTING-OUT AND PREPARING BUILDERS' JOINERY

Most of the subsequent workshop practice will be concerned with the whole or of some part of a constructional unit which is itself made up of parts fitted together. Careful and systematic setting out is necessary and it is well to arrange such setting out on lines which are customary in industrial practice.

Workshop Drawings and Rods. Scale drawings are supplied to the joinery department of a builders' works, usually in the form of blueprints. Certain essential measurements are set down, especially where the woodwork adjoins other trades, particularly brickwork. These scale drawings are not sufficiently detailed for the work to be marked out from them, and it is the job of a leading joiner or setter-out to prepare full-size drawings from which the timber will be marked out directly.

Joinery work of the simpler kind follows a well-defined pattern, and it is rarely that a picture of the whole piece of work is needed in the form of plans, elevations and sections. For instance, one casement window will be very much like another, and it will only be necessary to set down a vertical and a horizontal section of any particular job.

For this purpose a board 9 in. or more in width as required is generally used, and the two sections are set out together with any other essential information. The boards for these "rods," as they are called, are used over and over again by the simple process of applying a coat of whitewash when the rod has served its purpose, and using the new white surface for the next drawing.

Paper is sometimes used for rods, but there are several disadvantages attached to its use. It must be rolled and unrolled frequently; wear and tear of workshop use soon renders it bedraggled; paper contracts and expands considerably according to the humidity of the atmosphere; and in any case a flat surface will be needed upon which to lay it when marking out the work. So all things considered, a suitable size board is a much more satisfactory base for joiner's rods.

The instruments and technique used when preparing rods

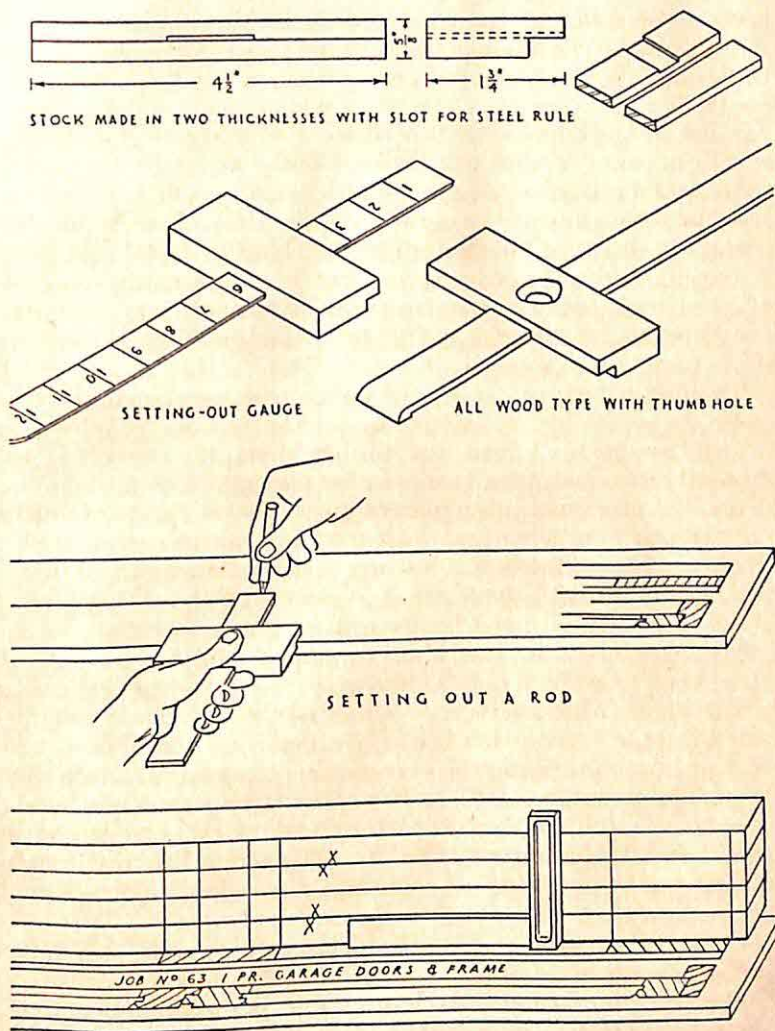


FIG. 19. SETTING OUT ON RODS: TOOLS AND METHODS

are a little different from those used on the drawing board. A try-square or a tee-square may be used for lines across the board, but set-squares are not much used. A form of pencil gauge is very convenient which enables long lines parallel to the edge of the board to be drawn (see Fig. 19).

As the same section will be used many times on the same rod, also on other rods, a setter-out will cut templates of certain sections from thin sheet zinc to save the time which would be needed in drawing each detail separately.

To summarize; a joiner's working drawing usually consists of a horizontal and vertical section of the job set out on a board 9 in. or so in width, and from this drawing or rod the timber is marked directly.

The following are some of the points to remember in setting out rods—

(a) The nominal sizes of timber must be converted to finished sizes, making allowances for planing.

(b) The precise position of over-all sizes must be ascertained, particularly for windows which may set into recessed brick-work or, alternatively, be set up first and have the square brick jamb built to them.

(c) Each section must be accurately drawn.

(d) When dividing for panels or glass panes, aim at getting all alike.

Casement Window. (Fig. 20). Prepare a joiner's rod for this example by drawing the vertical and horizontal sections. It will not be necessary to draw the plan of the sill on the horizontal section and if the board (or paper) is not wide enough, the full width of the sill need not be shown provided the dimension is figured in. Note that on the small scale drawing, nominal sizes of members are given; $\frac{1}{4}$ in. will be allowed on each width and thickness for planing.

Consult the larger drawings for details of mouldings, capillary grooves, etc.

One side of the window is shown divided into small panes and the other is left in large panes. Obviously this is alternative treatment and not intended for the same window.

It will be seen that ovolo mouldings are quarter ellipses and that capillary grooves are $\frac{1}{4}$ in. wide and $\frac{1}{4}$ in. deep. The method shown, that of drawing a $\frac{1}{4}$ in. circle for the capillary groove, gives the best results.

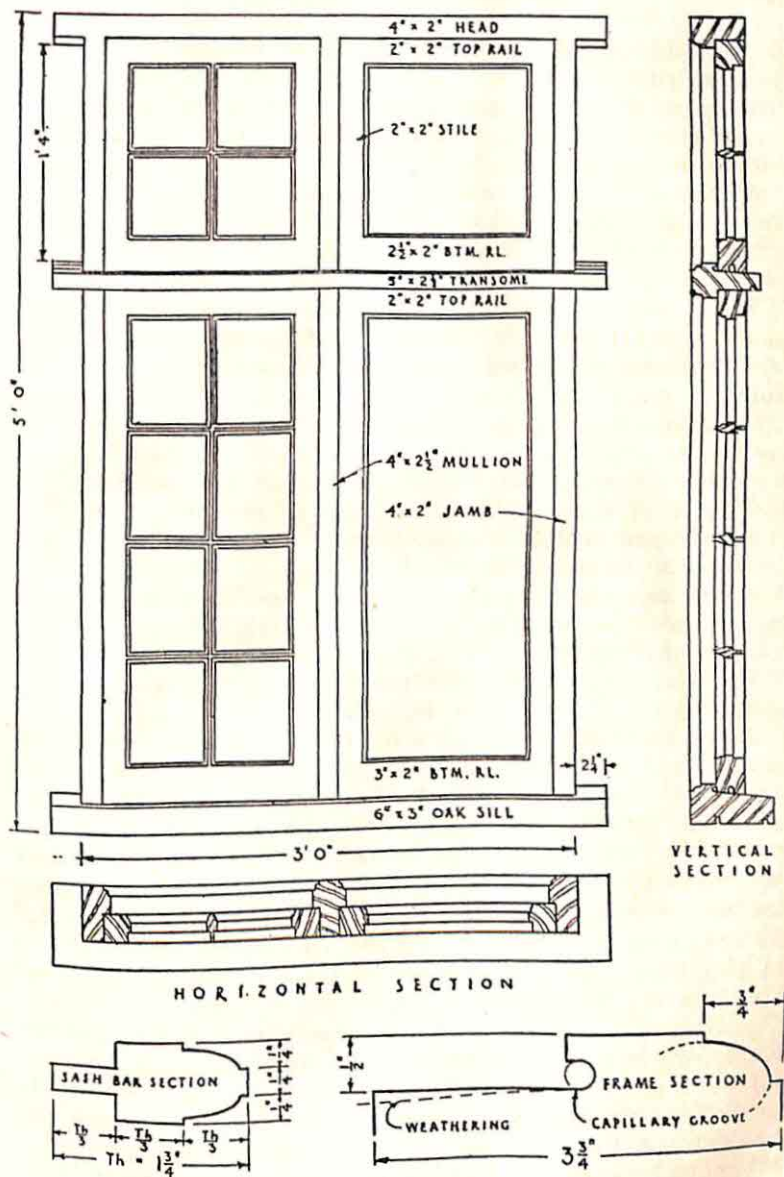


FIG. 20. SETTING OUT CASEMENT WINDOW

The rectangular groove shown on the underside of the sill is to accommodate the weather bar, which is to prevent the passage of moisture between two surfaces in close contact.

The thickness of the sash is divided into three—rebate, square and moulding. Whether each is exactly one-third of the thickness will depend upon the size of mortise chisel and moulding plane available, but equal thirds is a good general guide.

If possible use the correct technique in making the rod. That is, have tee-square and pencil gauges. Also use card or thin metal templets for drawing the sections.

When the rod is complete, take off a cutting list, using nominal size timber for cutting sizes and planed-up dimensions in the finished sizes column. In the last column, draw an approximate section of each piece, and prepare full-size tracings of each section for use of the machinist or joiner.

CASEMENT SASH JOINTS. Use one of the upper sashes of Fig. 20 as an example for practice. Figs. 21 and 22 show the method of jointing a casement sash.

The various members are set out in much the same way as for a door. The horizontal pieces are all marked together, and the vertical pieces similarly. As with a door, mortises are cut first, then tenons along the grain only. Next, rebates and mouldings are formed and then the shoulders may be sawn.

The method of making the intersections for the mouldings differs, however. The mitre templet is used as a guide for the chisel; the latter may be used only to make a mark on the moulding or to cut a mitre which provides the required outline for scribing. This process consists of taking a negative shape out of the end grain of the shoulder to make it fit over the moulding on the other member. A scribing gouge is used for the purpose on the rails, but the bars are not quite adapted to this treatment. With these, a coping saw may be used carefully to remove the waste.

Machine-made sashes have the scribing taken across the full width of the shoulders to the rails, but the hand-made joint is scribed only a short distance beyond the depth of the moulding. Note that the haunching is the opposite way about to that on a door joint. The reason for this is that removal of the central square on the sash, plus a groove, would weaken the stile unduly.

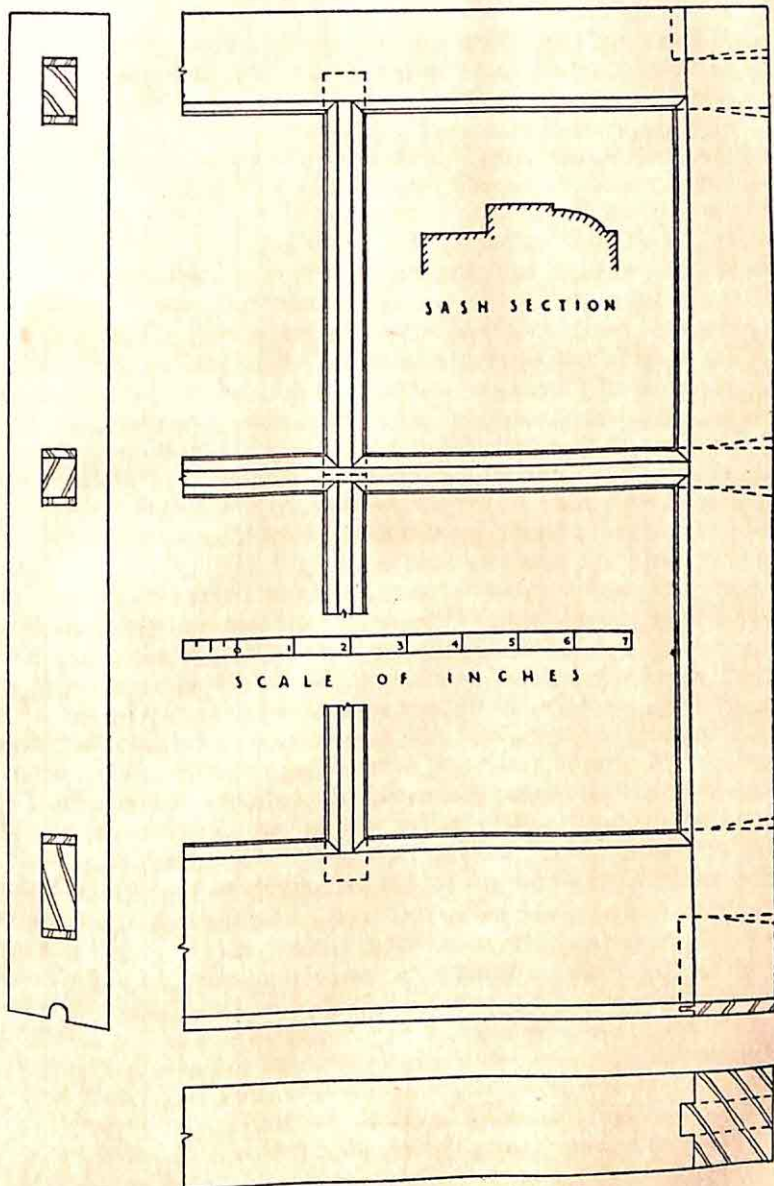


FIG. 21. CASEMENT SASH: GENERAL CONSTRUCTION

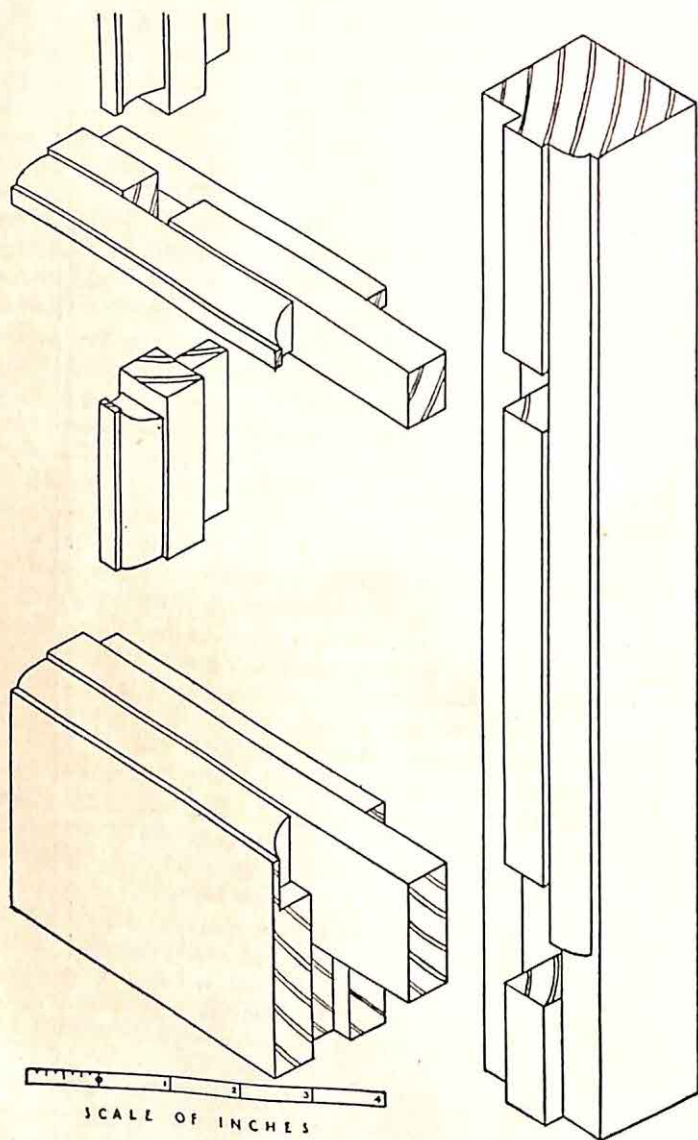


FIG. 22. JOINTS IN CASEMENT SASH

The joint shown where the bars intersect is the simplest of its kind. The tenons should be cut a little short of half-way through the mortise, to avoid them touching before the shoulders of the joint are tight and thus holding them off. Care must be exercised when wedging for, being slender, the bars will respond to pressure on one side or the other and assume a curved shape.

When all the joints are fitted and numbered, the inside edges should be cleaned up before glueing and fixing. For this purpose a glasspaper block is prepared from soft wood in the negative shape to the moulding. Fine glasspaper is wrapped around it, and the moulding cleaned up, paying particular attention not to destroy the sharp arrises. The central flat part is also cleaned up. In practice the rebate does not require cleaning, as the glass and putty occupy this space and any unnecessary work is merely wasteful. The faces of the sash are cleaned up after glueing and the capillary groove may be formed after the bottom edge has been planed to its necessary slope.

Cased Frame and Sliding Sashes. Where sashes are required to slide vertically they are arranged within a frame which is built up from thin material (except the sill) and is provided with recesses in which the sashes can slide. Parts of the structure forming the recess or groove can be taken out for inserting and removing the sashes when desired. Fig. 23 shows the general arrangement.

The vertically sliding sashes are each counterbalanced by a pair of weights, the sashes and weights being attached to one another by sash cord running over pulleys. The frame is designed around this mechanism, having a box or casing at each side to house the weights and allow them to pass easily up and down. One can imagine the clinking noise which would be occasioned by two cast-iron weights frequently passing each other in a confined space. To prevent this happening a long thin sliver of wood called a parting slip or wagtail is placed between them inside the box, suspended by a floor nail.

Referring to Fig. 23 the principal parts of the frame are seen to be a sill, a pair of pulley stiles and a head. The pulley stiles are housed, wedged and nailed into the sill, and housed into and nailed to the head. So far, this construction is not

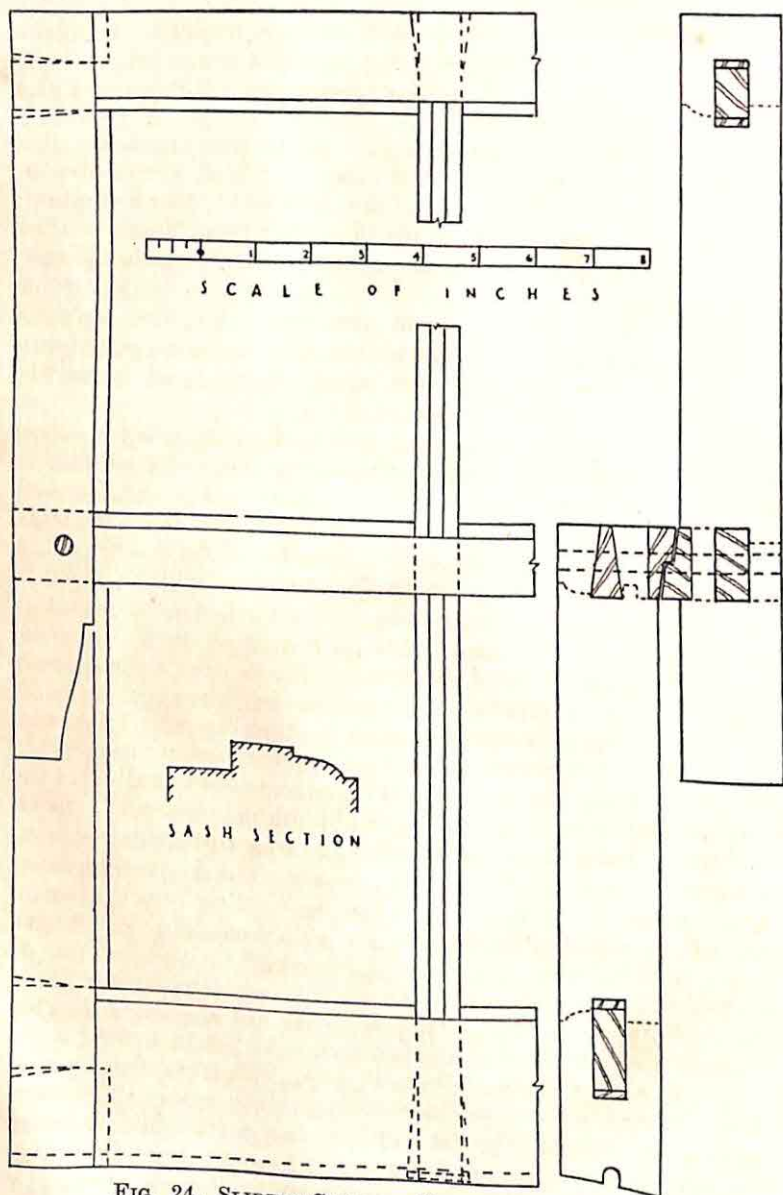


FIG. 24. SLIDING SASHES: DETAILS AND JOINTING

easily upwards and downwards. The top sash (which is on the outside) has the stiles continued at the lower end to form moulded horns. This allows an ordinary scribed mortise and tenon joint to be used.

The top end of the lower sash is neater if made without a horn. As the meeting rails are kept as thin as practicable so as not to exclude light nor look clumsy, the joint is made by dovetailing as shown in side elevation. Fig. 25 shows the joints of the sash separated, so that they may be clearly understood.

In the following paragraph the setting out of a cased frame and sliding sashes is described. (This should precede the construction of any part of the job when the whole example is to be constructed.)

CASED FRAME. *Setting Out* (see Fig. 23). The working drawing for this example is the usual rod consisting of a horizontal section and a vertical section. The height and width may be taken over all where the frame is to be built into square brickwork jambs; or may be taken inside pulley stiles for recessed jambs, and under head to under sill. The easiest procedure once these details are settled is to build up the thickness thus: outside lining $\frac{3}{4}$ in., sash $1\frac{1}{4}$ in., parting bead $\frac{3}{8}$ in., sash $1\frac{3}{4}$ in., inside lining $\frac{7}{8}$ in. The positions and sizes of other parts then fit in readily. Set out the details of the sill and head complete before deciding where to put the meeting rails. These are arranged so that glass sizes are equal. Be sure to make the rebate and slope at the meeting faces so that the sashes may open. Indicate positions for cord pulleys and weight pockets on the rod, and be sure the latter are long enough to admit the weights easily—say, as a general guide, 16 in. long.

Marking Out. Cased frames are an exception to the usual rules. It is best to work all the members to their required section before doing any marking out or cutting for joints. (*This of course applies to the frame and not the sashes.*) The members may then be marked out and the joints formed.

Cutting and Assembling (see Fig. 26). The trenches in the sill are made wide enough to accommodate pulley stiles and wedges, and $\frac{3}{4}$ in. to 1 in. deep at the shallow end. The head is grooved $\frac{1}{4}$ in. deep, and pulley stiles cut to length accordingly. Pulleys are housed in by first mortising for the wheel casing,

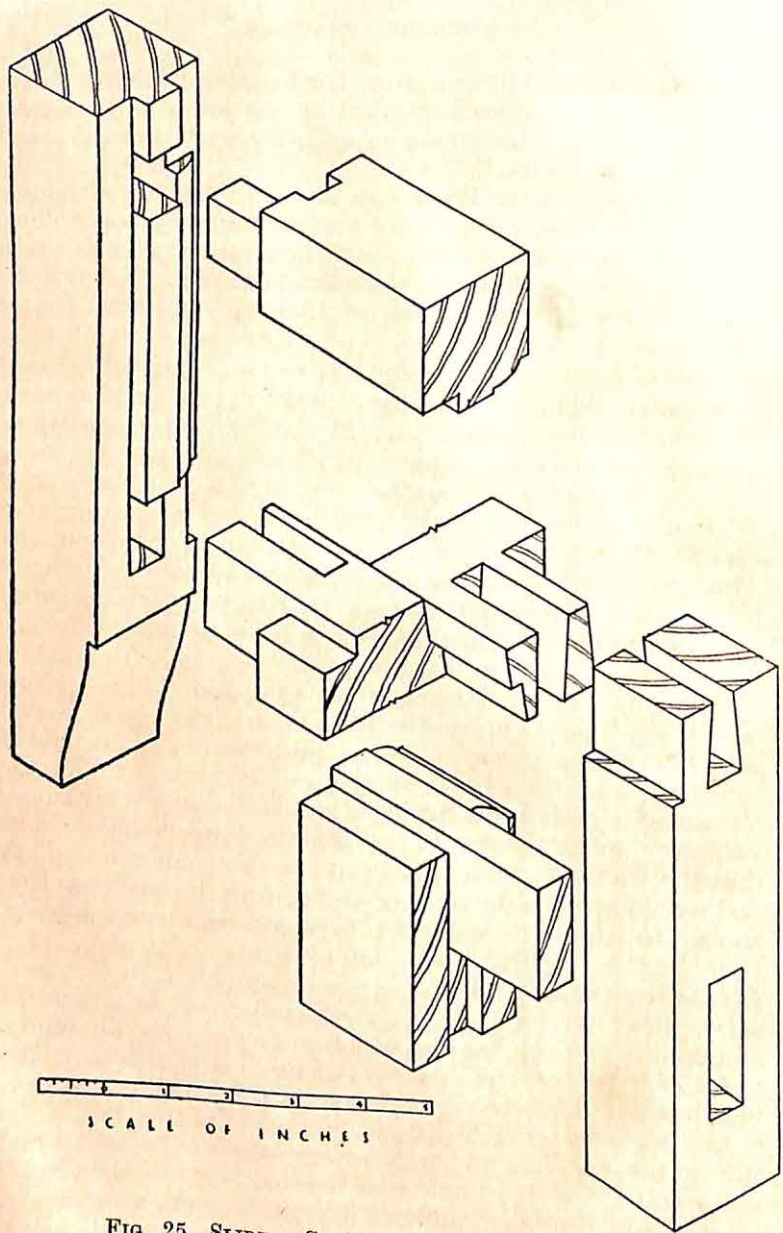


FIG. 25. SLIDING SASHES: WITH JOINTS SEPARATED

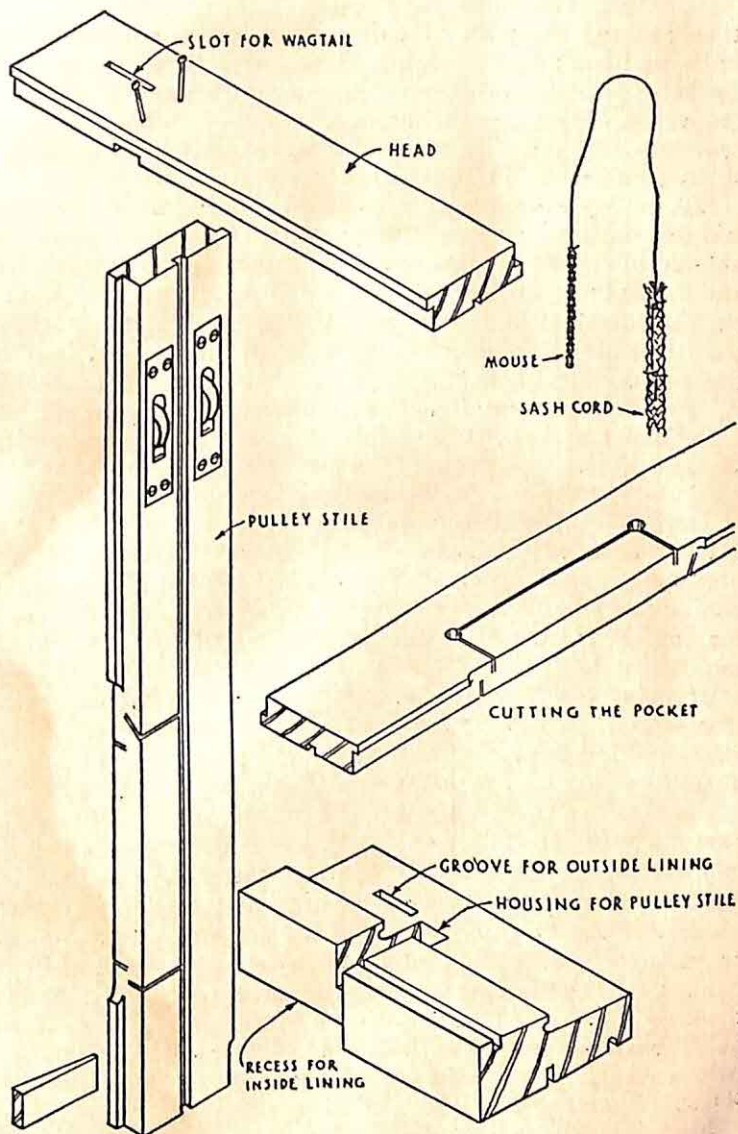


FIG. 26. CASED FRAME: DETAILS OF CONSTRUCTION

then pushing the pulley in, drawing a line around it with a knife and making the sinking for the plate to these lines. Pockets are cut by boring a hole right through the central groove, sawing along this groove, and then making the four crosscuts either with a saw or a pocket chisel. Mortises (or slots) are formed in the head for the wagtails.

Sill, pulley stiles and head should now be fixed together, laid flat on the bench and temporarily fixed square while the outside linings are nailed on. The frame is then turned over and inside linings nailed on. A few light taps with the hammer should be sufficient to complete the severing of the pockets. Guard beads (also called staff heads) are mitred in, but the top parting bead is cut in square and the uprights scribed to it. Put in the wagtail before nailing linings back on, and glue-block the head. The sashes when ready are planed to fit, and the projecting portion of the meeting rails removed at each end sufficient to allow the sashes to slide past the parting beads.

The job of hanging the sashes on cords is best left until the glazing is done, usually on the building; if necessary, before obtaining weights, each sash is weighed. Special lead weights can be cast in a piece of channel section steel, and holes bored for the cords, finally cutting to the length which gives the required weight.

Hanging the Sashes (Fig. 26). A "mouse" is needed for this job. This may be a short length of chain, or a piece of lead covering from electric flex, attached to a string and capable of passing over a pulley into the casing.

Remove the sashes, the upright pieces of guard bead and parting bead, and the pockets. Attach the free end of the mouse string to the length of cord and put the mouse into one outside pulley, drawing mouse string and cord through the pocket. Pass over to the opposite side and do the same, drawing the cord right round; follow up with the two inside pulleys. *All this is done without any cutting or untying.* Detach the string, pass the end of the cord into a weight, knot it and pull the weight up inside the casing. Determine the length of cord needed, cut it and nail it temporarily to the casing. Do the same for the other three.

By this means no cord need be wasted, nor any time in tying and untying. The cord is now attached to the sashes with 1 in. clout nails leaving the top part free to run over the pulleys.

Pocket, guard and parting beads are replaced in order. Much the same method is used when making repairs, the old cord being removed by cutting the sashes free and gently lowering the weights to the bottom of the casings. It is considered not worth while renewing one cord at a time; when one fails, all are due for renewal, and in any case the whole job should take about half an hour.

Vertically sliding sashes are often described as old-fashioned and out of date. They are certainly old-fashioned, as are many other very good things, but it is doubtful whether better windows have yet been designed for many purposes. The first function of a window is to admit light; compared with wooden casement windows, this type needs less intermediate frame members, and is therefore more efficient. The second function is to ventilate. As you will probably be aware, the air we breathe becomes warmed and rises due to its lowered density; another cause of air movement is the open fire, which needs a stream of air to sustain it. Now whether warm air rises to the top of the room or passes up the chimney, vertically sliding sashes are the most readily adapted to releasing stale air near the ceiling and to ensuring the entry and diffusion of fresh air to replace that which is lost. The word diffusion is used in preference to draught, for if either sash is moved a little, there is no direct opening to the outside, but a baffled opening is made at the meeting rails. By increasing the depth of the guard bead at the bottom this opening can be increased, still without a direct draught being caused.

For dwelling houses, hospital wards and for many other purposes this window is still the best. Its disadvantages lie in the need for periodical renewal of the cords and the consequent disturbance of paintwork in dismantling beads and pockets. This trouble is largely obviated by using cups and screws instead of nails in the guard beads.

VENTILATORS AND ROOF CONSTRUCTION

The examples immediately following require some applications of solid geometry which, it is assumed, will have been a subject of special study during the school course, either independently or as a section of mathematics. If satisfactory preparation in geometry has not been accomplished, these examples should not be undertaken.

Louvre Ventilators. In situations where the inside of a building must have a direct permanent opening to the outside, but it is necessary at the same time to exclude driving snow and rain, boards are built into a frame at a fairly steep angle. The boards are usually made to overlap but with clear spaces between. A typical example is a belfry.

If the frame is rectangular, the ends of the louvre boards are square, and the grooves in the frame sides are cut at an angle. Other shapes which are sometimes used are circular and triangular. These are suitable for gable ends of buildings and both are a test of the skill and geometrical knowledge of the craftsman. Only the triangular frame is included here, being typical of the construction used (see Fig. 27).

TRIANGULAR FRAME. This involves considerable preparation at the drawing stage to find the necessary bevels. The example shown has only three boards; if a bigger frame carrying more boards is desired, one should aim at excluding horizontal daylight spaces by having the top edge on one board *at least* up to the level of the lower edge of the next above.

BEVELS. The louvre boards are inclined at 45° ; therefore the true width is not seen on elevation, but must be obtained from the section and projected across. Note that front and back edges are seen in their true length in the elevation, so that when the board is drawn its real width, the correct bevel on the ends is found by joining the back and front edges by a line. The edge bevel for the boards is obtained similarly; that is, by projecting the true thickness across to the elevation and joining top and bottom edges. (Compare the results obtained with those for a similar case but with louvres sloping at some other angle than 45° .)

The section of the frame shows a foreshortened view of the sides. The elevation shows the correct length; therefore imagine one side turned flat on elevation and project one of the grooves on to it. The correct bevels for the grooves are then obtained. The shoulder bevel for the dovetail is obtained similarly; that is, by projecting the appropriate points over and joining by a line.

As will be seen on the plan, the groove in the sill is not at right angles to the edge, but runs outwards. This is because the *top of the sill is sloping*; therefore the farther the side runs *downwards*, the farther it runs outwards.

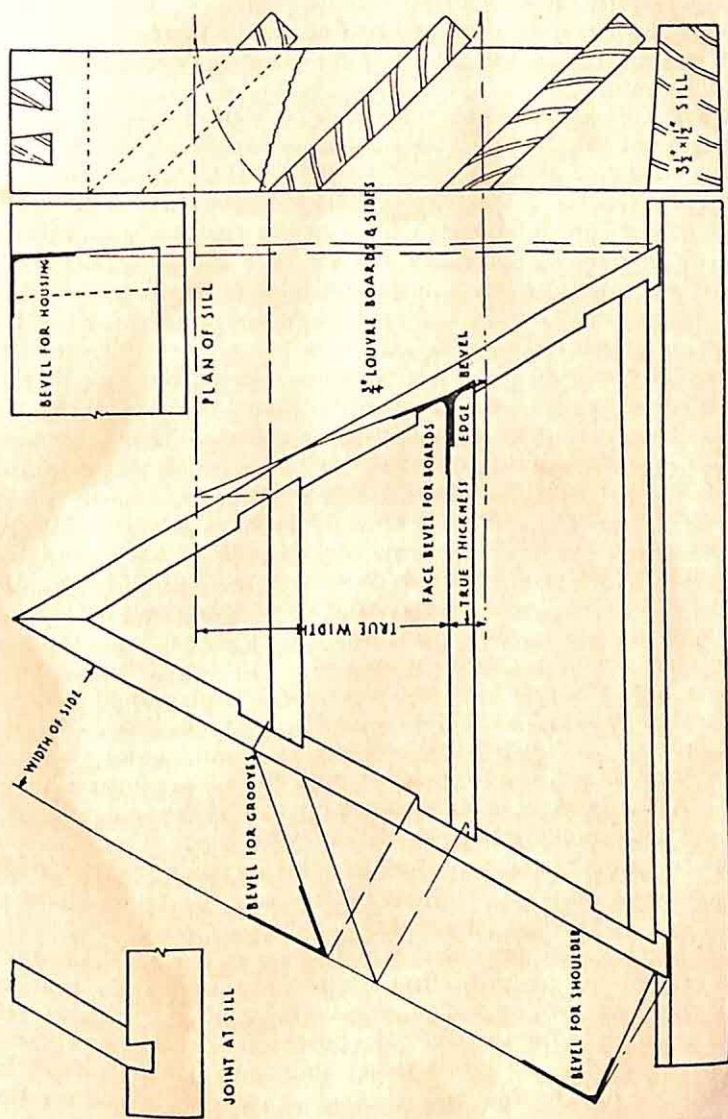


FIG. 27. TRIANGULAR LOUVRE VENTILATOR

For those who wish to be especially precise, an alteration in this bevel may be obtained by finding the increase in width due to the slope of the sill; but the effort may not be repaid by the result.

Construction. When the members have been planed up, set out and cut the dovetails on one end of each side; mark their shape on the edge of the sill. Saw part of the stopped housing and chop out the rest. Now set out the grooves and dovetail joint at the top, holding the sides in the vice, paired. Either saw or pencil marking may be used for the dovetails, but pencil is probably easier. It is advisable to clean up and fix the frame permanently before cutting the louvre boards to fit. The length of each may then be taken directly from the frame. By sawing a little full, the ends can be accurately fitted with the plane and the boards pushed in from the front. Nails are used to fix them. The final operation is planing the louvre boards flush at the back.

Model Roof Construction. By far the best practice in roofing is gained if full-size unplaned timber is used. This method is not as wasteful of timber as at first appears, for the timbers can be used many times over by constructing a roof of such a span and pitch as to use its full length; on successive occasions the span or the pitch or both may be reduced, and only a little need then be cut away to waste. Another advantage is that a low grade timber can be used. Such a model as is illustrated in Fig. 28 is suitable for the purpose.

If lack of floor space makes large-scale models impossible, there are other alternatives; the roof can be made to a suitable scale, for example one quarter full size. Failing even this, a small scale model (1 in. = 1 ft) may be made; but in this case, to gain reasonable practice in jointing, the timber sections will need to be to a larger scale, say one quarter full size.

Setting Out. An accurate scale drawing of the roof showing plan and elevation is the first need. If a small-scale roof is to be made, a large sheet of plywood will serve the dual purpose of a drawing medium and a base for the model. Larger roofs will need a scale drawing on paper and a full-size lay-out with chalk lines on the floor. All bevels and lengths should be determined on the drawing; if the steel square is to be used, a check is available in the early stages.

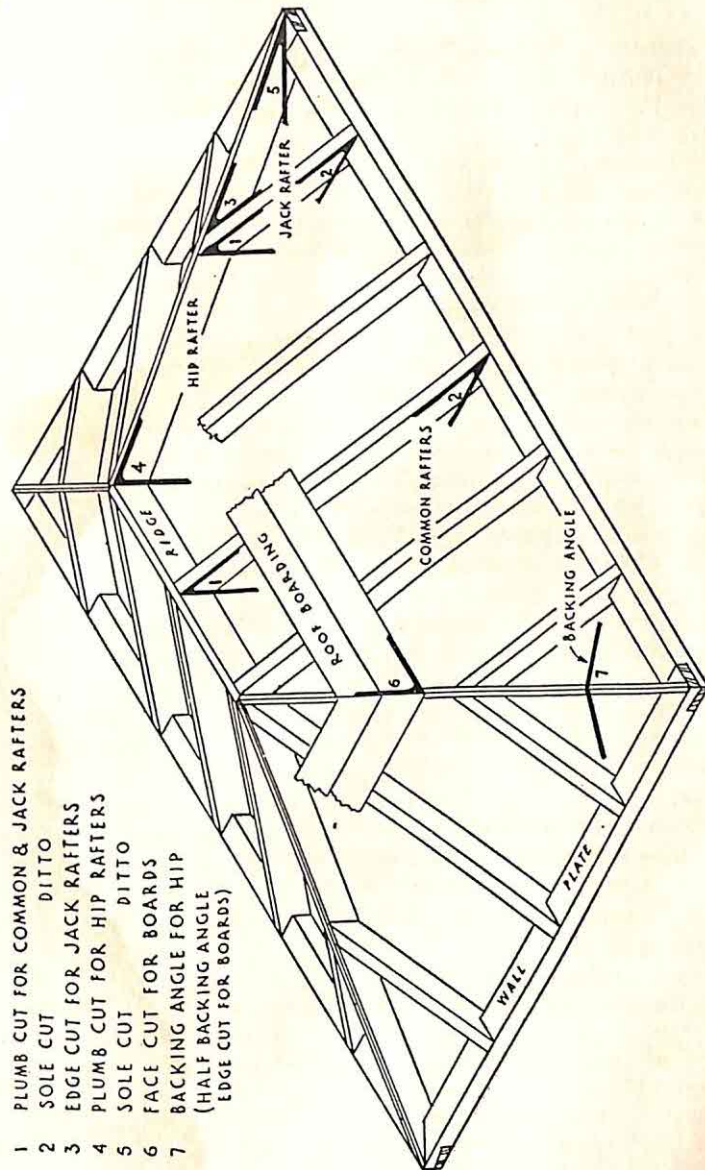


FIG. 28. MODEL OF HIPPED ROOF, SHOWING BEVELS

Construction. The wall plates should be "lap-dovetailed" at the corners and fixed to the base (whether the floor or plywood sheet). It will be necessary to keep the wall plates square and level. Any variations in these conditions will throw the whole construction out badly.

At least two pairs of common rafters should next be prepared, to the length and bevels required, not forgetting to deduct the half thickness of ridge at the tops. The ridge can be cut to length, bearing in mind any allowances for the hip joints.

By measuring back from the corners, the exact position of the first pair of common rafters at each end is determined and these and the ridge may be put in position and fixed. Temporary braces from the wall plate to the back edge of the rafters may be used to keep the position of the ridge truly plumb over its plan position, while the hip rafters are prepared and fixed.

Fig. 28 shows typical methods of arranging and fixing the top ends of the hip rafters. Plumb lines and bobs hung from the end of the ridge will be a good check until the hips are fixed.

The longest jack rafters are now prepared and fixed, and the whole roof will be held firmly whilst the rest of the common and jack rafters are put in. Purlins are not included at this stage.

The construction as outlined follows normal practice very closely. Such members as ceiling joists and collars are put in at the same time as common rafters. Eaves construction is then done and boarding last of all. If the eaves construction is to be added to the model a selection may be made from Fig. 77. The model needs to be lifted from the floor or board for this to be done.

Suggested sizes. For the full-size roof 4 in. by 2 in. or 3 in. by 2 in. may be used for the common timbers, while the hips and ridges may be 9 in. by 1½ in. and 7 in. by 1 in. respectively. The span is arranged to suit timber lengths and available space, and the amount by which the length is made to exceed the span, will determine the length of the ridge.

For the 1 in. = 1 ft model, 36 ft by 24 ft overall size is the smallest to be aimed at; it should be larger if possible. Quarter-full-size sections will give 1 in. by ½ in. common timbers.

SCALE MODELS

Ground Floor Fireplace. Model making is an important part of the joiner's craft. It provides interesting work and often requires great skill.

When an architect has designed a large building, it is quite usual for a model to be made to scale of $\frac{1}{2}$ in. = 1 ft, showing all details on the outside and possibly the surrounding ground and trees. Other models may be made of the interiors of some of the important rooms. From these models architect and client can criticize and modify details if necessary. Incidentally photographs can be taken and the appearance of the finished building determined before it is even started; where it is of sufficient interest, pictures may be published in the technical papers along with the plans. Another use for models is for demonstration purposes in technical classes to show items of construction in buildings.

It will therefore serve two useful purposes if models are made in the workshop. The nature of the work can be better appreciated by the model maker and the models can be used in other classes.

The isometric drawing of a ground floor fireplace (Fig. 29) is a suitable example and is easily constructed; it could be made to take to pieces to show points of structural detail. A suitable scale would be $1\frac{1}{2}$ in. = 1 ft. As far as possible plywood and block board are used, with battens between. The main wall of this model and the chimney breast could be formed of these materials with solid material for the fender wall, sleeper wall and joists, and for the foundation and hearth concrete. A batten under the base board (surface concrete) at the outer edge would maintain the model on an even keel. Each part should be made detachable, with pins to locate its position for assembly.

For finishing the model, suitable colours and textures can be applied in paint so as to imitate materials other than wood; and, given the requisite patience, all or part of the brickwork bonding could be shown by painted lines for the mortar joints.

The honeycomb wall may be constructed as follows. Take as many pieces of wood as there are open courses, the correct width but $\frac{1}{8}$ in. thicker than the finished size. Hold them all together for marking and grooving out the spaces. By glueing

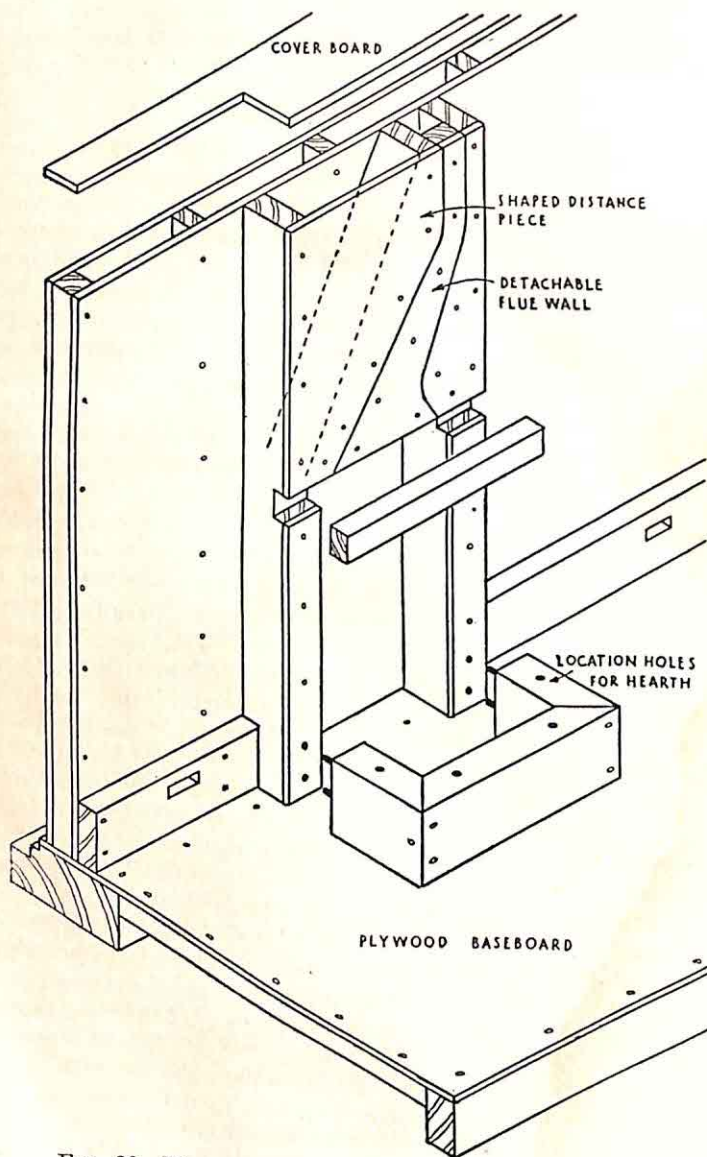


FIG. 29. MODEL MAKING: GROUND FLOOR FIREPLACE

one at a time, and leaving to harden, the spare $\frac{1}{8}$ in. may be planed off before the next goes on.

SMALL FURNITURE

Child's Chalking Board. Between two and eight years of age, a younger brother or sister will derive hours of pleasure using a chalking board and will at the same time be learning easily and naturally the art of self-expression. A suitable article is shown in Fig. 30.

Design. A big surface is most important. If more than one board is being made at a time, the normal sheet of plywood will cut into four of the size shown. The toddler can reach the lower part at 15 in. high and will be able to aspire higher with increasing stature.

The single board shown is quite firm with one back leg; but, if the family justifies it, a two-sided model may have two frames like the front one shown and a pair of hinges and cabin hooks. The tray could be set at a suitable angle to the framing to be horizontal when the easel is opened. If desired, a wood or iron bracket could be used to lend added strength to the tray in case the child should kneel on it.

Construction. Plywood and stump mortises and tenons will give mutual support and strength; through tenons are hardly necessary. Halving joints are an alternative. When the frame is glued and cleaned off, the board may be nailed on with French wire nails or fixed with small screws. In either case leave the heads standing a little and file flush with the surface. The back leg and fixing block are prepared and the backflap fixed. Bore two holes right through backflap and fixing block for securing the latter to the main framework. A recess in the muntin will allow the backflap to bed right in. The tray may be of $\frac{5}{8}$ in. material, or $\frac{1}{4}$ in. ply, secured to the framework with screws under the lower edge. A fillet surround is mitred at the corners and screwed on.

Painting. A special matt finish paint is required for the board surface. Several proprietary brands are obtainable. The usual two flat coats and one of enamel will be suitable for the remainder.

Child's Desk. *Design.* Simple sturdy construction is the chief consideration. The dimensions shown in Fig. 31 are based on the proportions of a child of seven or eight in the

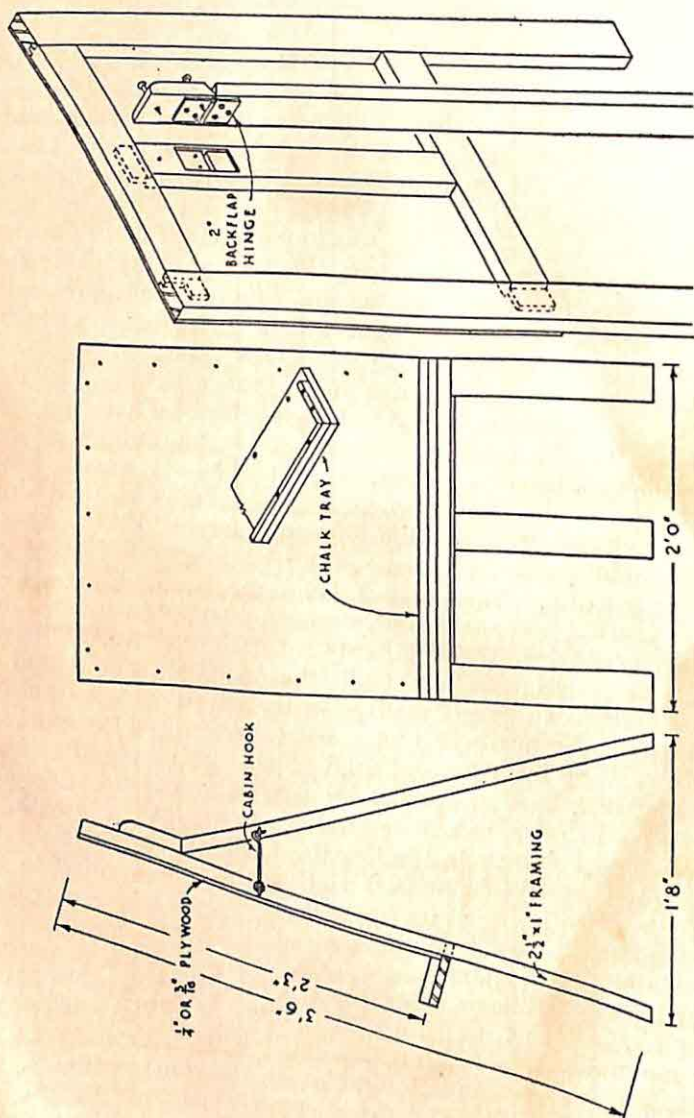


FIG. 30. CHILD'S CHALKING BOARD

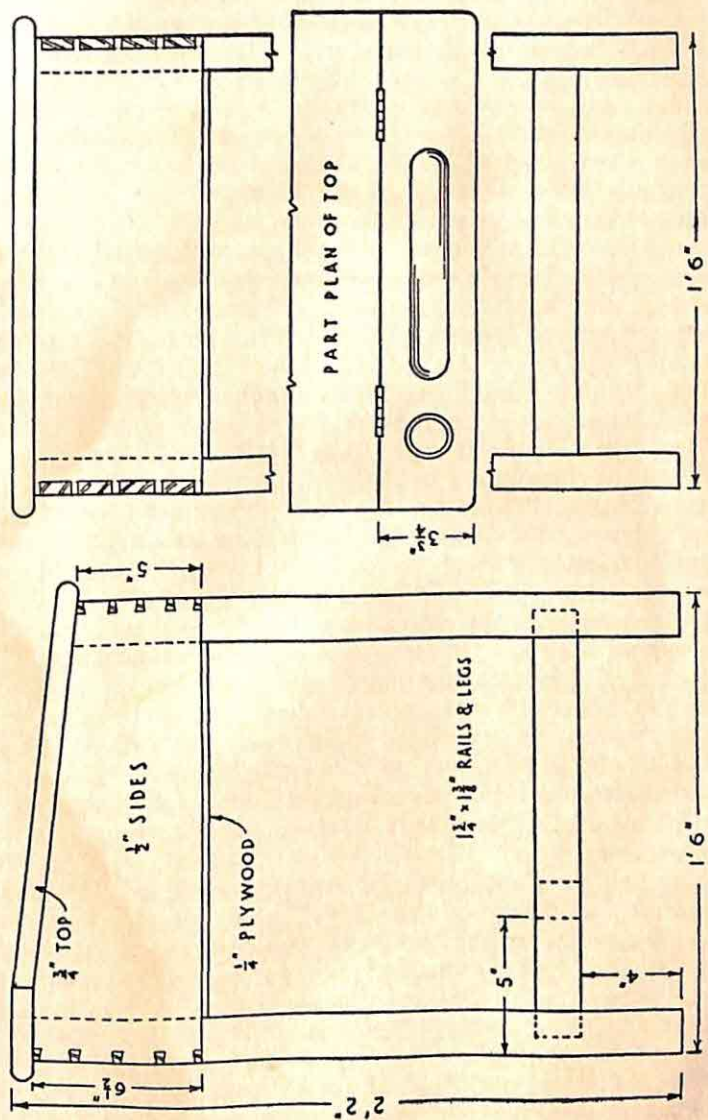


FIG. 31. CHILD'S DESK

sitting position. If necessary the sizes can be altered to suit any age. Sit the child on a seat of such a height that the thighs are horizontal, or running a little downward to the knee. The height to the top of the thigh plus clearance fixes the underside of the box portion. With the child sitting comfortably upright, measure to the under-side of the arm when in a writing position for the height of the top. A gentle slope is advisable, since a flat top encourages round shoulders and a sudden slope causes materials to slide off.

Construction. The lower portion is stump tenoned and the top ends of the legs are cut away to the thickness of the sides. The sides may be of $\frac{1}{2}$ in. material, dovetailed at the corners. The $\frac{1}{4}$ in. plywood bottom may be cut to fit after the framing is fixed, but a better method is to house it into the legs, the housing being formed diagonally across the section of the legs. In the latter case, the framing and bottom are put together and the box portion slipped over afterwards.

When they are glued up, two oval brads may be used to fix each stump tenon, preferably from the inside of the framing. Screws should be used to fix the box portion to the legs and for fixing the bottom securely to the sides. Two glue-blocks along each side will be additional security.

The narrow part of the top has a pen tray gouged out and a hole for an inkwell. One long screw into the top of each leg will fix it; to conceal the fixing, the screw heads should be sunk $\frac{1}{4}$ in. below the surface and a plug glued in the same way of the grain as the top.

The hinged flap is hung on 2 in. brass butts and the edges rounded afterwards; it can be detached again for this purpose. By this means the $\frac{3}{4}$ in. oversail can be made accurately if the surplus is left on the flap and a line drawn whilst a gauging fillet is held in position. Where unauthorized toddlers may pry into the desk, provide a box lock, and house into the front with the catch plate fixed under the top. The whole job should be given three coats of paint, the top one of best enamel, to enable it to stand up to hard wear.

Kitchen Table. *Design.* To be suitable for its purposes, a kitchen table needs to be sturdy, of simple outline, and easily cleaned. Yellow or white deal are both suitable timbers, but for air superior article, beech framing and a birch top would be better. For purely kitchen use, a white enamel top would be

an excellent alternative, and a shelf about 12 in. off the floor could be carried on rails tenoned into the legs; the latter construction would also give added strength. In some households, meals may at times be served in the kitchen; here a shelf would not be in order as the diners would have no knee-room. Several synthetic coverings are obtainable for domestic tops which are easily cleaned, but a very good plan is to have a special type of linoleum glued to blockboard, and a surround of hardwood mitred at the corners and fixed to the edges with brass screws. One drawer at the end is usual, but one at each end is a possible alternative; again, two might be put into one long side.

The table suggested as a constructional example is shown in Fig. 32.

Construction. Tenons may occupy the middle third of the rail, or a saving may be made on labour by having bare-faced tenons. As the mortises meet, tenons should be mitred as shown. The haunchings are bevelled to conserve the strength of the legs. Dowel pins are used to hold the joints; alternatively, drive two nails from the inside. Drawer rails have special joints; the lower rail should have two stops mortised in before assembly, the near side being set in a distance equal to the thickness of the drawer front. Suitable runners and kickers are screwed to the side rails.

The ordinary top is made of boards ploughed and cross tongued; if desired the grooves may be stopped short of the ends so that the joints are not visible on the finished article. Such a wide unit of wood will shrink and swell, so the fixing must be such as to allow lateral freedom. Buttons are prepared of hardwood and the mortises in the rails made wide enough to allow of movement. Fixing at the drawer rail should be through slotted holes for the same reason.

The drawer can be made last, and at this stage the student should be able to fit the drawer front tightly into the opening before the joints are made, subsequent fitting being thereby made much easier.

Best quality church oak varnish would be a good finish for the framing, but the top is left plain for scrubbing.

Drawing Instrument Case. For the instrument case shown in Fig. 33 12 in. is a suitable overall length, and the width is determined by placing the scale across the diagonal. (Shallow

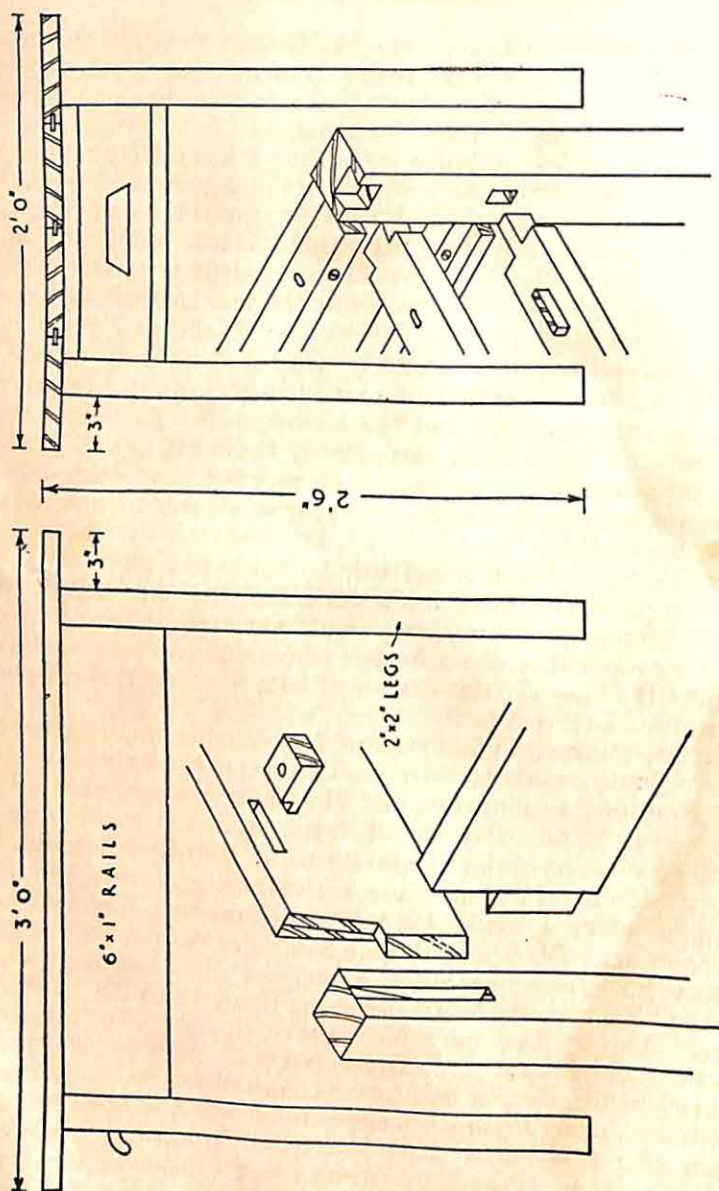


FIG. 32. KITCHEN TABLE

sinkings inside the lid hold the scale which is "sprung in" and retains the set-squares.) The depth of the case should allow for compass set, scale and set-square to fit in easily. (Allow $\frac{1}{8}$ in. extra for sawing lid.)

Mahogany is suitable for the sides of the box, which are rebated on both edges to hold the plywood; the latter should be faced with gaboon. The corners are mitred and glued, using corner blocks and cord for cramping (see below). When the glue is set, saw cuts are made into which pieces of veneer are glued. This type of joint is as strong as dovetails for light frames, and easier to make.

The plywood top and bottom are fitted in fairly tightly, glued and put under pressure until the glue is dry. Cleaning up can then be done, and the lid sawn off. The edges are planed, and $1\frac{1}{2}$ in. brass butts fitted. Brass catches are quite easily made with metal saw, drills and files, and a little lug bent at right angles for easy use; or small cabin hooks may be purchased.

An effective name panel can be made if a piece of thin celluloid is obtainable. A piece is cut of the required size, a knife line run around it, and a shallow sinking made. A paper label is prepared, and put in the sinking with celluloid on top. Finally the case should be stained with a good oil stain and french-polished.

Picture Frames. Patent cramps are available for putting the mitred joints together; none is so inexpensive as wood blocks and cord used as shown in Fig. 34. The joints are glued and the pieces put on a flat surface, with a block at each corner. A running noose enables the cord to be pulled tight, and by knotting on itself the tension is maintained while any adjustment of joints is made and the glue hardens. When glued joints are set, nails or screws may be driven in from both sides of each mitre, or a veneer tongue may be glued into saw cuts.

Other light boxes and frames, e.g. cigarette and trinket boxes and the like, may be made similarly. Two sets of blocks may be used for deeper boxes; and two or more veneer tongues can be arranged like dovetails for the joints. Quite a pleasant decorative effect is obtained if contrasting woods are employed.

Oilstone Case. For this purpose select a piece of straight grained hardwood about 2 in. longer than the oilstone, about

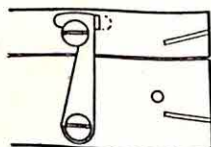
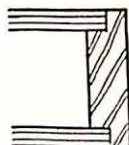
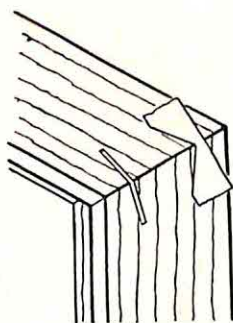
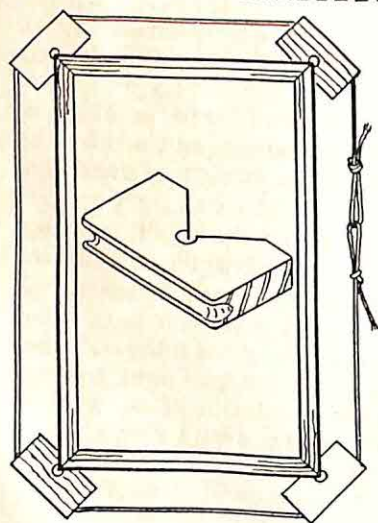
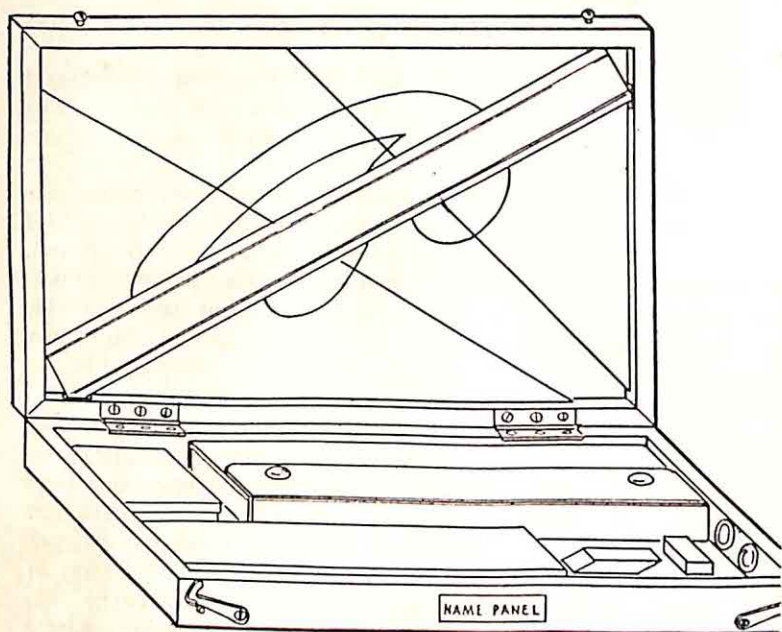


FIG. 33. DRAWING INSTRUMENT CASE
FIG. 34. PICTURE FRAME

1½ in. wider than double its width and of sufficient thickness to allow ¼ in. top and bottom when hollowed out (see Fig. 35).

When marking out, allow ¼ in. extra length at each end for the wood slips, and gauge the width lines to give a tight fit. It is worth while to set out the holes accurately for boring out the waste, for by boring the largest holes possible much laborious chopping out is saved. Centre and twist bits are not suitable for this job, as the central point goes deeper than the cutter portion. The Forstner bit or a morse drill will be suitable. If the latter is used in a drilling machine the holes can be taken to a suitable depth by using the depth stop on the machine. Failing this a depth gauge can be fitted to the bit. The waste is removed by vertical paring with a chisel and working to depth with a router plane. The stone must fit fairly tightly into the lower part, but be an easy fit in the lid.

Wooden end slips are a distinct advantage, enabling the whole length of the stone to be used, thus saving it from becoming hollow and preventing the accidental stubbing of keen edges on the end. When these have been fitted in, assemble the whole case, plane the edges and square up the ends.

If desired, the edges of the lid may be moulded, but a chamfer or quadrant are both suitable. Finish the case with glasspaper and apply linseed oil occasionally. To prevent the case slipping on the bench, a panel pin may be driven a short distance from either end of the bottom and nipped off with the pincers. Another way is to glue a strip of cork lino underneath at either end.

Tool Case. The case shown in Fig. 36 is not intended to accommodate all the tools a carpenter and joiner is likely to need, but when full will contain quite enough for carrying about. The dimensions are fixed according to the individual tool kit. The inside length is arranged to take the hand saw or panel saw, while the depth should allow two planes to be put in easily side by side—say jack and smoothing planes plus ½ in. The suggested height is 14 in., as anything deeper is awkward to carry.

The four narrow sides should be of carefully selected ½ in. thick yellow deal or pine. The bottom is ⅝ in. narrower than the other pieces to allow for the ½ in. strip below the hinges. Mark the dovetails carefully, allowing a double pin and the

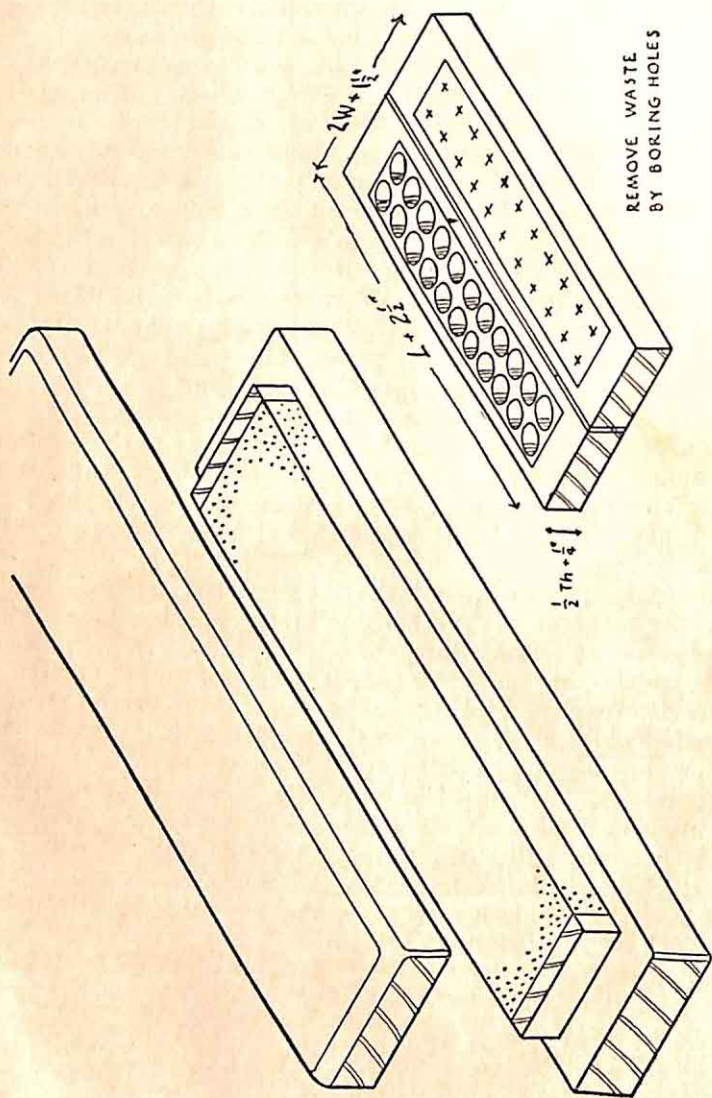


FIG. 35. OILSTONE CASE

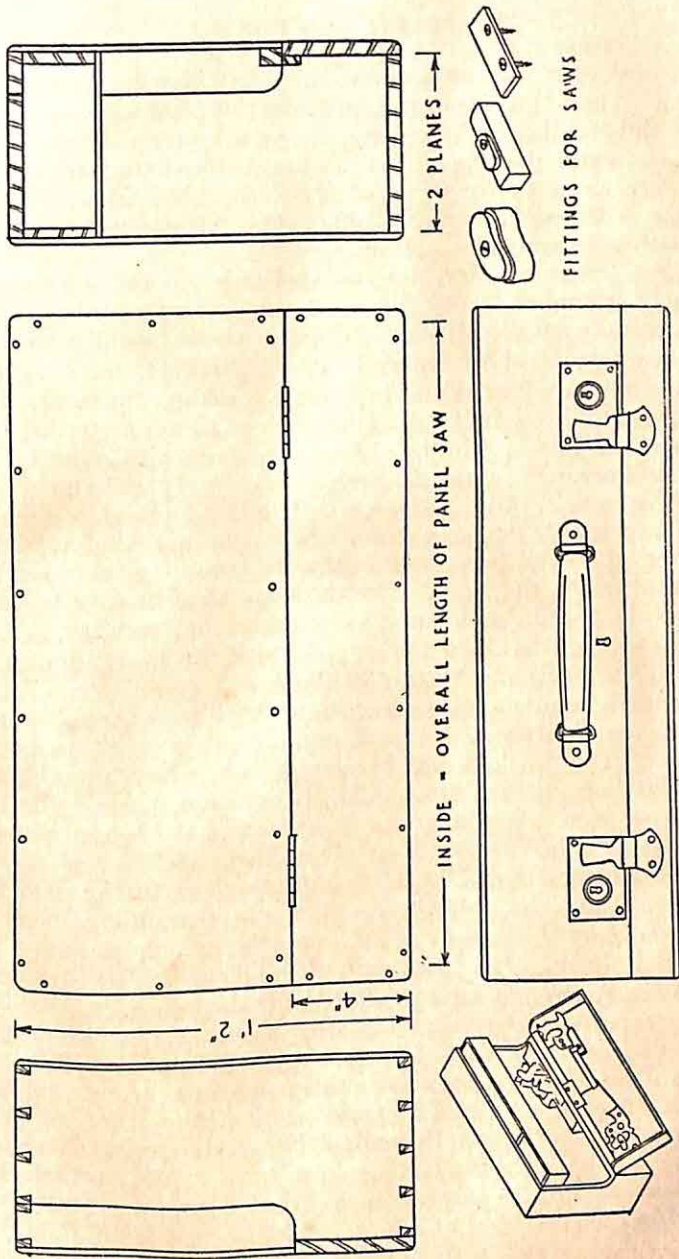


FIG. 36. TOOL CASE

thickness of a saw cut where the lid will subsequently be sawn. When the sides are glued, fix the plywood back with glue and small screws, keeping the case square. Prepare the $\frac{1}{2}$ in. strip and glue the hinge fillet to it before fixing to the case with screws. Saw the curve at the base of the lid with a fine coping or fret saw, then fix a hinge fillet to the plywood for the lid with glue and small screws.

When the glue is dry, the case is cleaned up and the corners slightly rounded. Any screw heads standing above the surface may be filed flush. The lid is then carefully marked and sawn to meet the curved saw cut. Hinge and hang the lid and prepare fixings and buttons for holding the saws. The till for holding small tools may be of $\frac{3}{8}$ in. material; its runners, of $\frac{1}{4}$ in. $\times$ $\frac{3}{4}$ in. hardwood, are fixed with screws.

Furniture. Purchase a suitable heavy type handle and locks from a leather goods shop. The bag locks should be of the type which lie on a flat surface, but the kind used for leather cases can be adapted by using a piece of plywood for packing under the hasp. Screws or split rivets may be used for fixing handle and locks. For additional security, a box lock may be fitted. To prevent damage, fit four "domes of silence" to back and bottom of the case.

Remove handle and bag locks and finish with three coats of paint, the final coat being a middle oak varnish paint or enamel. The finished article should bear a fair resemblance to a leather suitcase and could on occasion be used for the same purpose. A smaller model is very handy as a general purpose attaché case.

Step Ladder (Fig. 37). The example given in the drawing is small and light, but for rough work on buildings heavier sections may be used. For domestic use, however, 1 in. material finishing at $\frac{7}{8}$ in. will be sufficiently sturdy—and quite heavy enough for carrying about the house.

The tapered design is used in order to ensure that the weight of a load on any part of the steps shall be well within the point of support. To emphasize this point, imagine what would be the effect if a pair of steps were made the other way up. Obviously a load put on the end of the top step would cause the steps to topple over. If the sides were made parallel this effect would not be so pronounced, but it would be sufficient to make the steps feel unsafe.

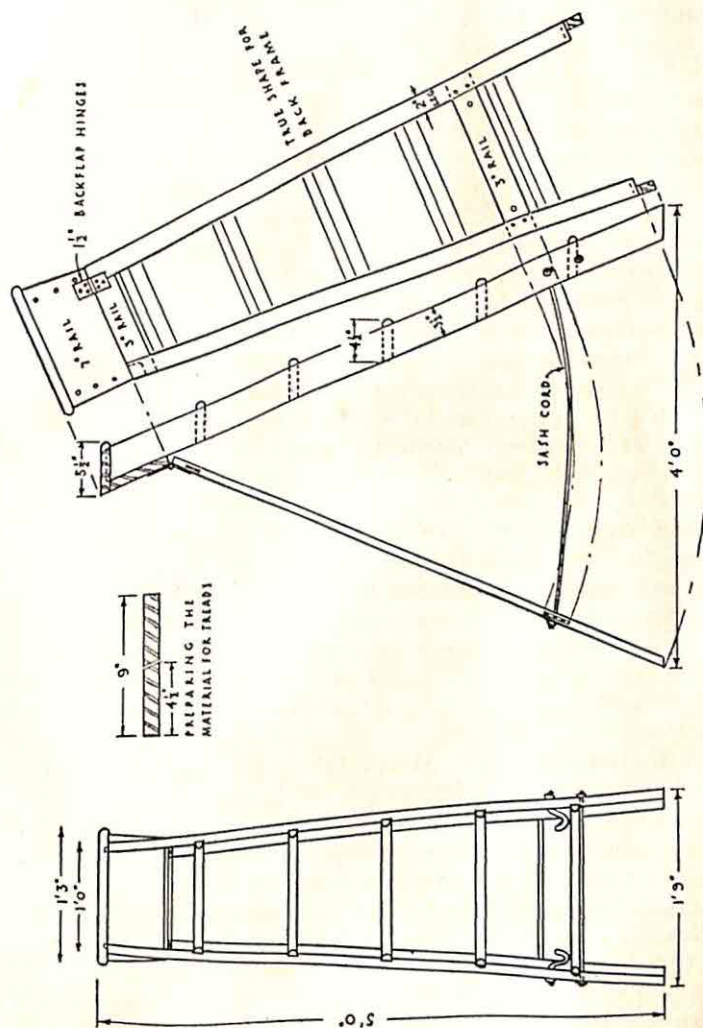


FIG. 37. HOUSEHOLD (OR BUILDERS') STEPS

When setting out the main legs, it will be satisfactory to mark the apparent lengths and bevels from the side elevation although the true length is slightly longer (about $\frac{1}{8}$ in.). The legs should be put face sides and edges together and the grooves marked on the edges first, with a bevel obtained from the true shape; this will be the same as the shoulder bevel for the back frame. The grooves are marked across the faces and gauged $\frac{1}{4}$ in. deep on the edges. It is advisable to mark the grooves $\frac{1}{8}$ in. to $\frac{1}{32}$ in. smaller than the tread thickness to ensure a really tight fit. A tongue is formed at the top of each main leg, to fit into a groove on the underside of the top step.

The treads should be cut about 1 in. longer than the required finished length and held together in the vice with all square edges uppermost. By using a spare piece of the same thickness as a bottom tread to represent the floor, the bottom length of each step may be marked by two lines connecting the top with the bottom distance. Nails or screws are used to fix the treads and the diagonal distance checked before fixing the wide top rail at the back with screws, as this rail is intended to brace the main portion.

It is a good policy to lay the members of the back frame in position on the main portion when marking out, allowing $\frac{1}{8}$ in. extra on the width on each side for final smoothing. The mortise and tenon joints may be wedged, but should be pinned with hardwood dowels as well.

Final details include fixing the backflap hinges, chiselling the ends of the treads to a neat curve, and boring the holes and fitting the sash cord stretcher. The $\frac{1}{4}$ in. rod underneath the bottom step is worth while adding to hold the main frame tightly together. Cut the rod $\frac{1}{8}$ in. longer than the width plus the thickness of two washers and burr the ends over with a small ball pane hammer (the type plumbers use).

Plasterers' and Bricklayers' Hawk (Fig. 38). The material for the square top should be yellow pine if possible, but a good quality yellow deal is a fair substitute. The clamp and handle are suitably of beech or ash.

If the tapered clamp is made first, it can be used to mark the groove accurately upon the underside of the top (using the narrow side in doing so). In this way, a shaving or two is available for a final fitting.

The handle should be planed to the correct taper, but

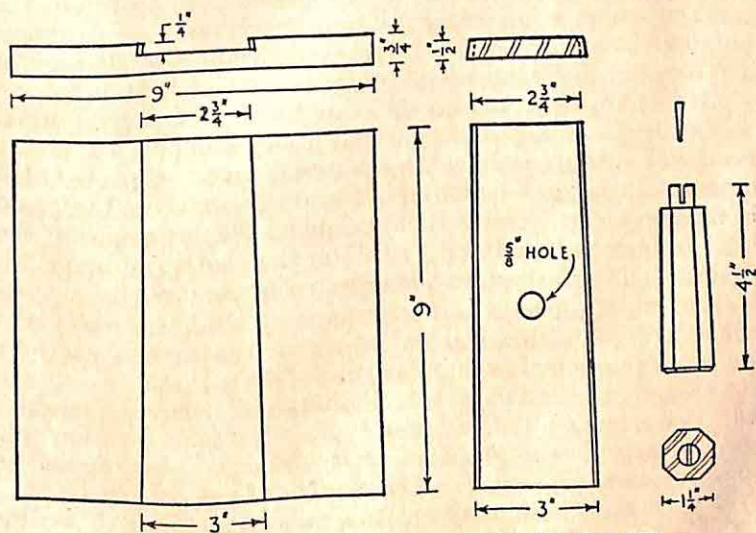
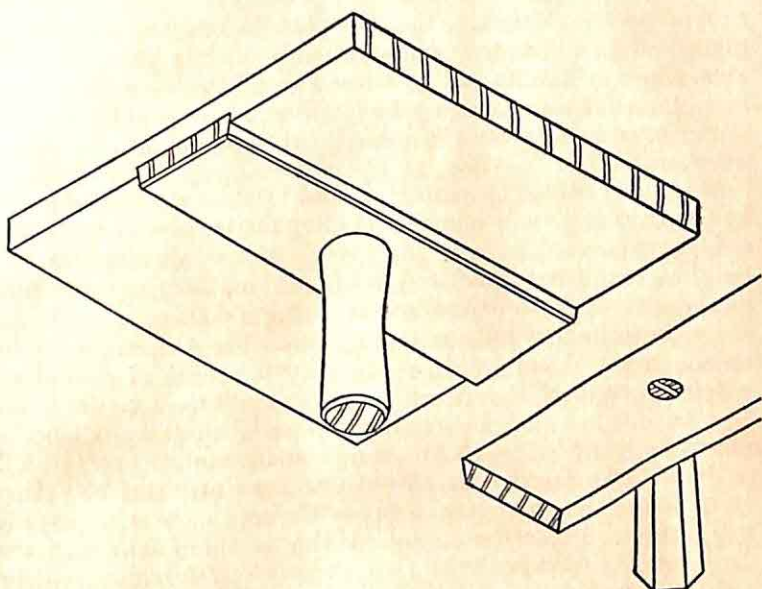


FIG. 38. HAWK FOR PLASTERER OR BRICKLAYER

square in section at first, the four corners being subsequently planed off to obtain the octagonal section. If a lathe is available, a round handle can be turned complete with pin. It is essential that the wedge which secures the handle to the clamp is placed across the grain; otherwise it will split the wood.

Many other tools for plasterers and bricklayers can be made by the carpenter and joiner, including floats, plumb rules and straight-edges. This service to colleagues working on the building is much appreciated, and provides the carpenter and joiner with opportunity to do others a good turn.

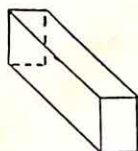
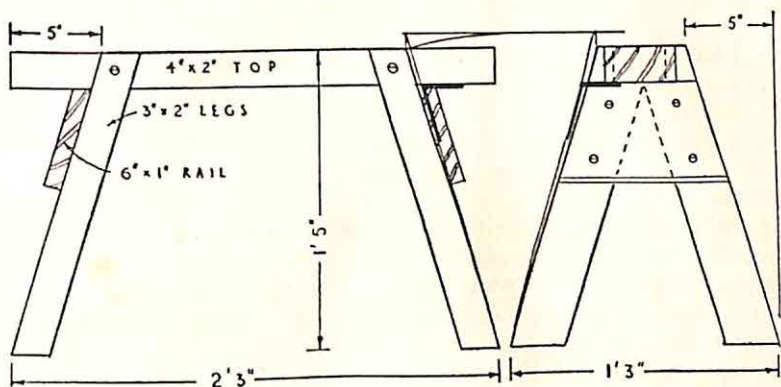
Carpenter's Sawing Stool (Fig. 39). For the stool to be thoroughly rigid and stable when in use the legs should be splayed outwards both in width and in length. Sometimes the legs are made parallel at the sides, but then the stool has a tendency to tip when weight is put on the end.

When the legs are splayed both ways an ordinary elevation gives neither true length of legs nor the correct bevels to apply for cutting. These are found by the methods shown in the drawing, i.e. by swinging the length shown in the side elevation into a vertical plane, and projecting this height over to the end elevation; the true length and bevels are then available because the true shape of the plane containing the outer surface of the legs has been obtained.

Although rectangular on the plan, the section taken normal to the leg is not rectangular but rhomboidal. To find the necessary angle to which the material must be planed, the dihedral angle must be found in a manner similar to that used in roof problems. The vertical height of the outer edge of the leg is set on its horizontal "run" on the plan. The perpendicular height of a section plane taken at right angles to the true length of the edge is then swung into the horizontal plane which gives the dihedral angle, i.e. a true section at right angles to the outside sloping edge.

The grooves in the top which house the legs may be marked out with a bevel obtained directly from the side elevation and gauged $\frac{1}{2}$ in. deep. The legs are best marked *in pairs* to a templet made from plywood or cardboard.

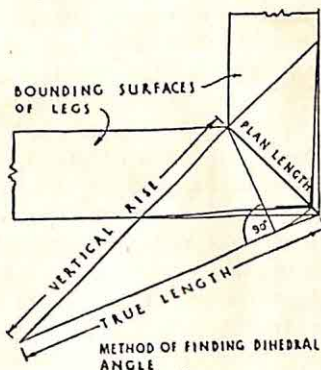
It is not advisable to cut the rails to net length before fixing. Bevel the top edge and, holding the piece in position, mark the rail to the legs. Cut a little full of the line and plane



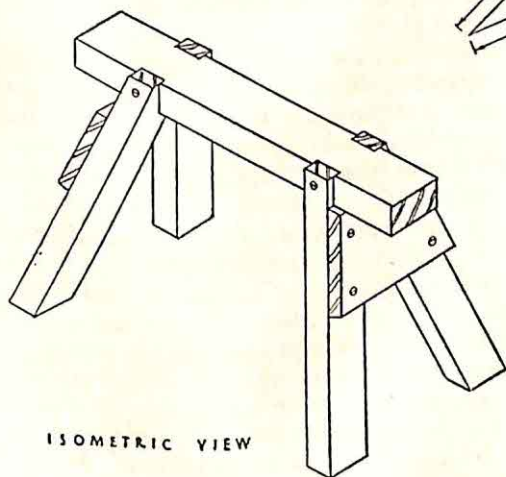
PLAN OF LEG
(RECTANGULAR)



TRUE SECTION
(RHOMBOID)



METHOD OF FINDING DIHEDRAL
ANGLE



ISOMETRIC VIEW



PLY OR CARDBOARD TEMPLAT

FIG. 39. CARPENTER'S SAWING STOOL

off the surplus after fixing. Screws are the best fixing, as a sawing stool has to stand considerable rough handling and nails soon work loose.

Although, to be strictly correct, the material for the legs should be planed to the dihedral angle, most stools have been made without this refinement, and the same applies to the true bevels for the legs. The differences are so small, and often the stool has to be made so quickly, that balancing a reasonably effective job against economy of time and effort, square section legs and the apparent bevels are used for the sake of speed.

As the student will be making a first-class job with reasonable time in which to do it, however, the last paragraph will not apply for the present.

Splayed Linings. The reveals to window openings are either plastered on the inside, or wooden linings are used. In order to obtain extra light, and dispel shadows between windows and in the corners of the room, the reveals may be splayed, thus making the opening wider on the inside. Stone window openings were so treated before glass was invented; those used for defence purposes in particular being very narrow outside but wide inside to accommodate the defenders.

Wooden linings would be used in conjunction with wall panelling, and might also themselves be panelled. For the purpose of illustrating the main shapes and bevels required, a lining with a plain face has been selected (Fig. 40). The section shows the correct width of the lining; to obtain the proper shape where head and side linings meet, this true width must be brought into the elevation. The length of front and back edges is seen correctly in elevation, hence by connecting these lengths with the true width we obtain the true angle of intersection or face bevel.

Similarly for edge bevels. When viewed directly in front, the mitred joint appears to be at 45° , but this only holds good if applied to the finished edge. When cutting square-edged material this angle would not be correct. The amount the bevel runs along the edge is shown in elevation; if this is used in conjunction with the true thickness found from the plan, the edge bevel is obtained. The tongue and groove joint appears square on the finished edge, but when making the joint on square-edged material it will not be so.

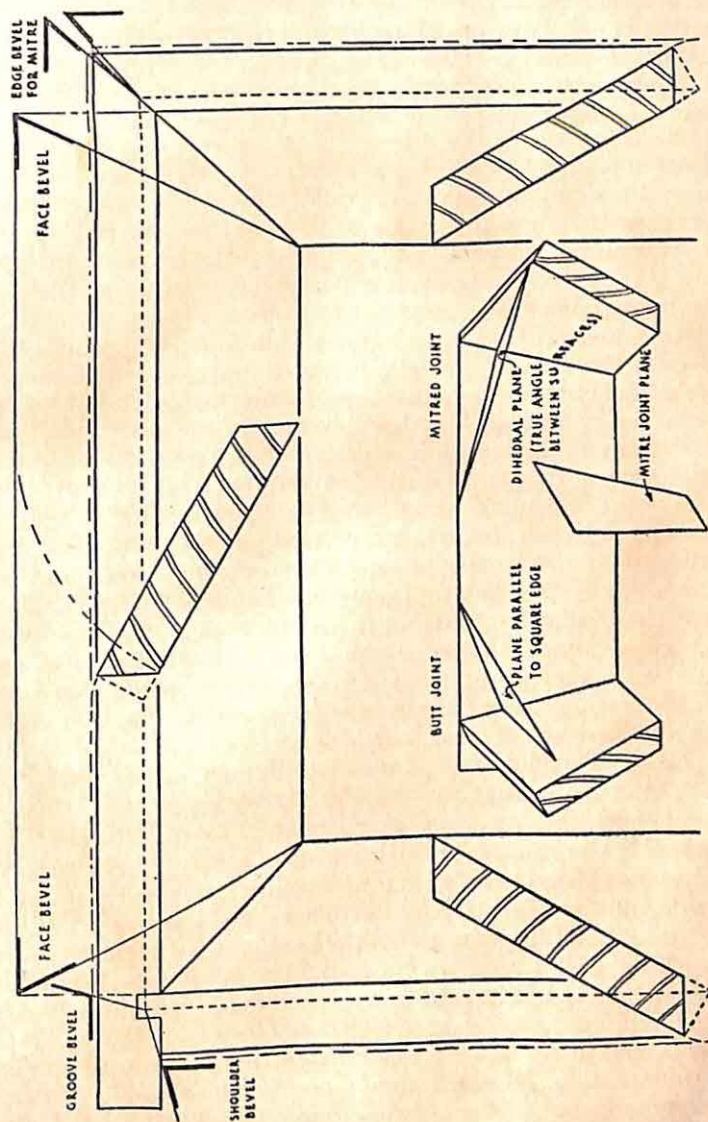


FIG. 40. SPLOYED LININGS

Project the square edge into elevation and obtain the apparent bevel. Now project the true thickness of the material into elevation and use the same run of bevel in conjunction with the true thickness to obtain the correct bevel. Although two bevels have been obtained and are shown, one for the shoulder and one for the groove, they are really at the same angle of cut.

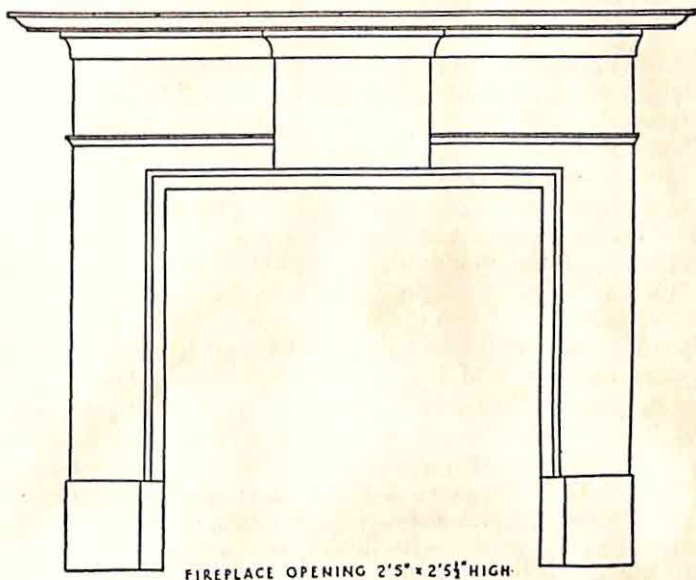
When the linings are made, it would be a valuable experiment to prepare templets in cardboard of (a) the dihedral plane (the true angle between the plane), (b) of the plane which passes through the mitre joint, and (c) of a plane parallel to one square edge and lying between the surfaces with one edge on each. These will indicate alternative methods of obtaining the bevels and will prove valuable in the general study of bevels for splayed work.

Further applications of the above principles are found in boxes having splayed sides, e.g. hoppers, troughs, etc., and in other types of joint—for instance dovetailed corners, and plain butted corners, nailed or screwed.

Chimney-piece. Fig. 41 represents a chimney-piece or mantel to be constructed in wood. The opening sizes would be made to suit a metal or tiled fireplace surround (either full size or to a reduced scale) and the moulding arranged to form $\frac{1}{2}$ in. rebate to cover the joint. Frieze rail and jambs are jointed with mortise and tenon joints and fixed with screws from the back. The upright returns are butt-jointed and glue-blocked to the framing, while plinth blocks are recessed about $\frac{1}{4}$ in. and put on the same way of the grain as the jambs to ensure even movement.

Shelves may have mouldings worked on the solid and returned at the ends, but if many breaks around pilasters etc., are involved, or if the shelf is fairly thick, they may be built up with soffit and cover boards with cross bearers around which a separate moulding is mitred. Pocket screws and glue-blocks secure the shelf to the main framing. The central panel is fixed with glue and panel pins, and finally mouldings are mitred and fixed similarly.

The type of chimney piece illustrated is of simple design and construction; but of course many elaborate and beautiful pieces may be found in superior domestic and other buildings, some of which incorporate bookshelves and little niches for



FIREPLACE OPENING 2'5" x 2'5½" HIGH.

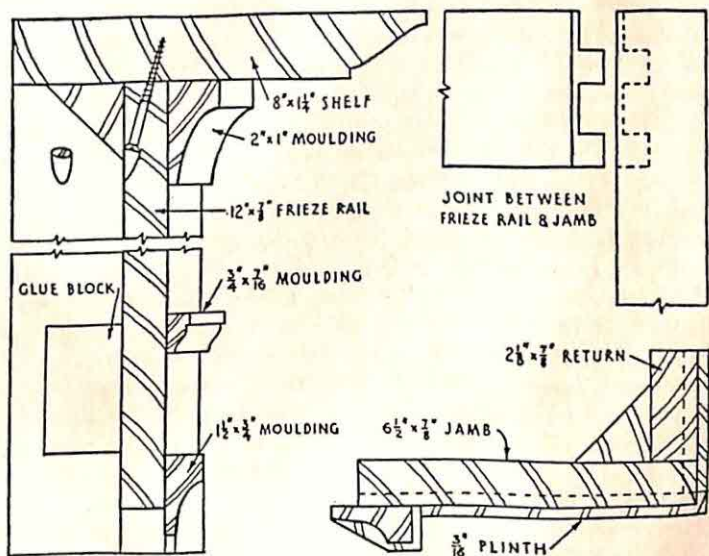


FIG. 41. MANTEL OR CHIMNEY-PIECE

the kind of oddments one needs when sitting by the fire. More elaborate chimney-pieces may have turned columns, decorative pilasters, carvings and other enrichment. When it was fashionable to ornament this type of work, enrichment applied to quite expensive pieces was made of "carton-pierre" or other composition material which could be readily shaped by modelling or pressing into moulds.

Yellow pine or at least a good quality yellow deal is used for pieces intended for painting, and a suitable hardwood where intended for polishing.

Fixing. Blocks are secured to the wall in such a position that the returns to the jambs hold the chimney piece in the desired position. Screws are then fixed through the returns into the blocks. For painted work the plasterer may finish up to the woodwork, but for polished work the plastering should be finished true before fixing takes place.

The more common types of fireplace finish, e.g. cast-iron mantels and tiled surrounds, have disadvantages when compared with wooden chimney-pieces. Cast-iron fittings are produced to stock patterns by the thousand and the designs consequently cater for very limited tastes. Tiled surrounds, though often quite pleasing in themselves, have an annoying disposition to clash with normal colour schemes.

Display Cabinets. A display cabinet suitable for showing sports trophies, books or specimens of various kinds is shown in Fig. 42. It should be made in oak or other hardwood. The carcase should be dovetailed at the corners; the common dovetail is quite sound, but to some minds unsightly. The joint can, however be hidden; as the top and bottom of the cabinet will not normally be seen, it is sufficient if the pins are stopped $\frac{3}{16}$ in. short, much as the dovetail holes are in a lapped dovetail (see left-hand drawing). If desired the joint can be entirely concealed by stopping both tails and pins; while, in another variation, the portion above the pins may be run up flush with the side and the corner rounded to obviate end grain.

On the right hand of the drawing a mitred or secret dovetail is shown as an alternative. It is prepared as follows. The ends having been shot square, a rebate is formed on the end grain of both pieces and the joint made, using the pencil marking method. Mitres are sawn at all four corners and a steel shoulder plane used to form the mitres along the edges.

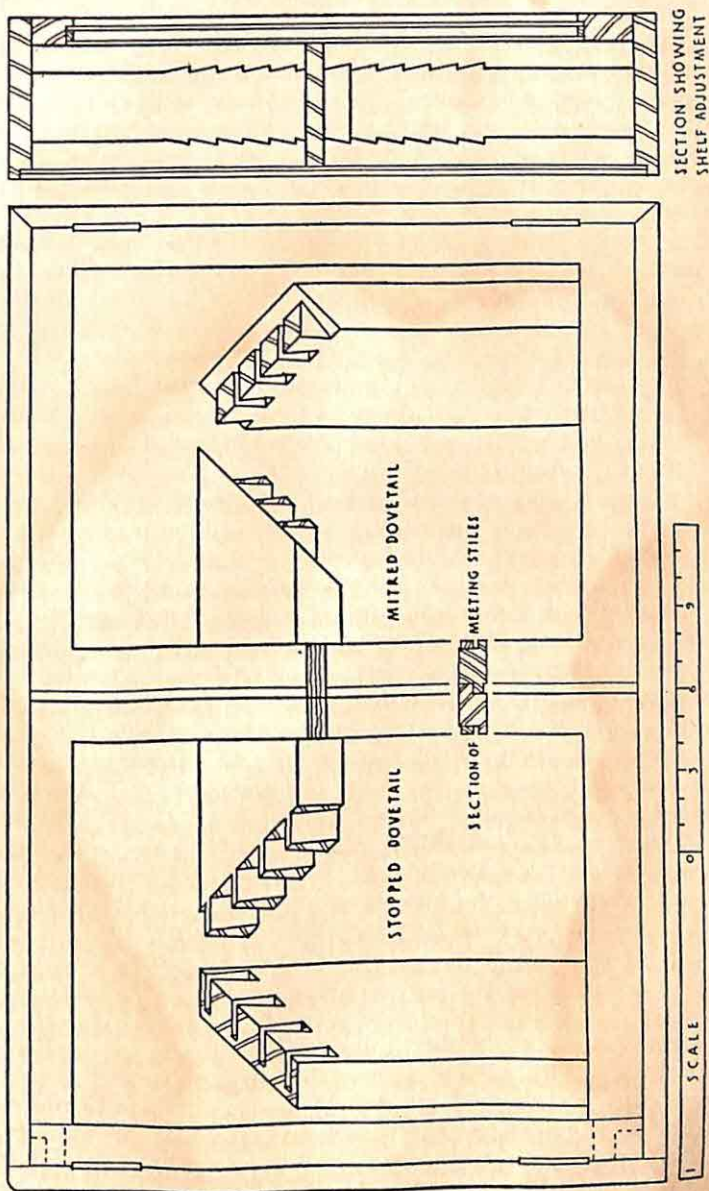


FIG. 42. DISPLAY CABINET

Shelves may be housed permanently, or may be made adjustable by fixing $\frac{1}{4}$ in. saw-edged battens inside the cabinet, one at each corner as shown. The shelf bearers have bevelled ends to engage in the notches. An alternative method of supporting shelves consists in having short lengths of $\frac{3}{8}$ in. dowel engaging in holes bored in the sides (at about 1 in. centres).

It is not necessary to rebate the sides if saw-edged battens are used, as these will provide a fixing for the back. The top and bottom can be stop-rebated about 1 in. short of the inner corner and a corner of the plywood back removed to suit.

Notice Board (Fig. 43). This should be framed in oak, with stub tenon joints fixed with screws from the back. Stiles are recessed after the joints have been made and the lettering carved. It is advisable to draw the lettering on paper, using carbon paper to transfer the impression on to the wood. Carving of letters should be practised on a spare piece of wood with carving tools, carefully sharpened and kept to a keen edge by buffing on leather. Previous to carving the lettering, the framing should be cleaned up. It must *not* be glasspapered; glass particles are fatal to keen cutting edges.

For pinning up notices, a soft backing to the green baize is desirable; soft laminated board may be suitable, but pressed paper or fibre board is probably better. The paterae at the corners are optional; they may be raised above the surface by glueing the piece on the face, or they may be recessed.

Demonstration Slide Rule. A model slide rule to a large scale is intended, as shown in Fig. 44.

(1) Any number can be expressed as a power to the base 10, e.g.

$$100 = 10^2$$

$$1\ 000 = 10^3$$

$$10 = 10^1$$

the small superior number following 10 in each case being called an index.

Multiplication may be performed by the addition of indices e.g. $100 \times 1\ 000 = 10^2 \times 10^3 = 10^5$ or $10^{2+3} = 100\ 000$.

Division may be performed by the *subtraction* of indices e.g. $10^7 \div 10^3 = 10^4$ or 10^{7-3} .

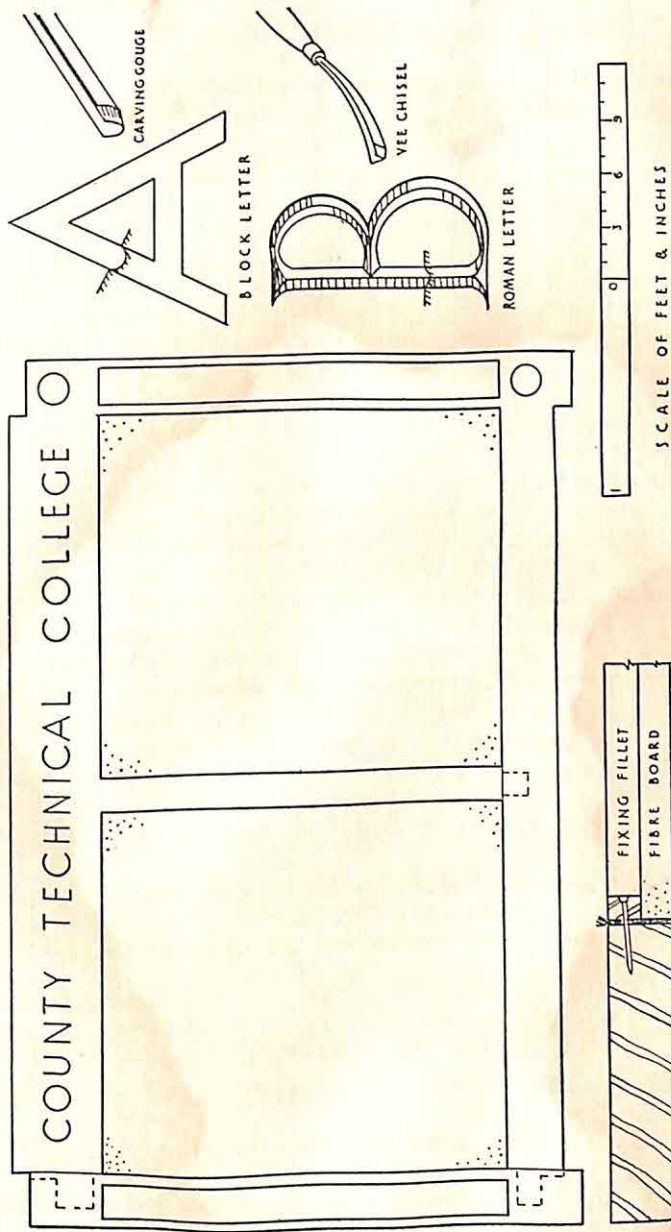


FIG. 43. NOTICE BOARD

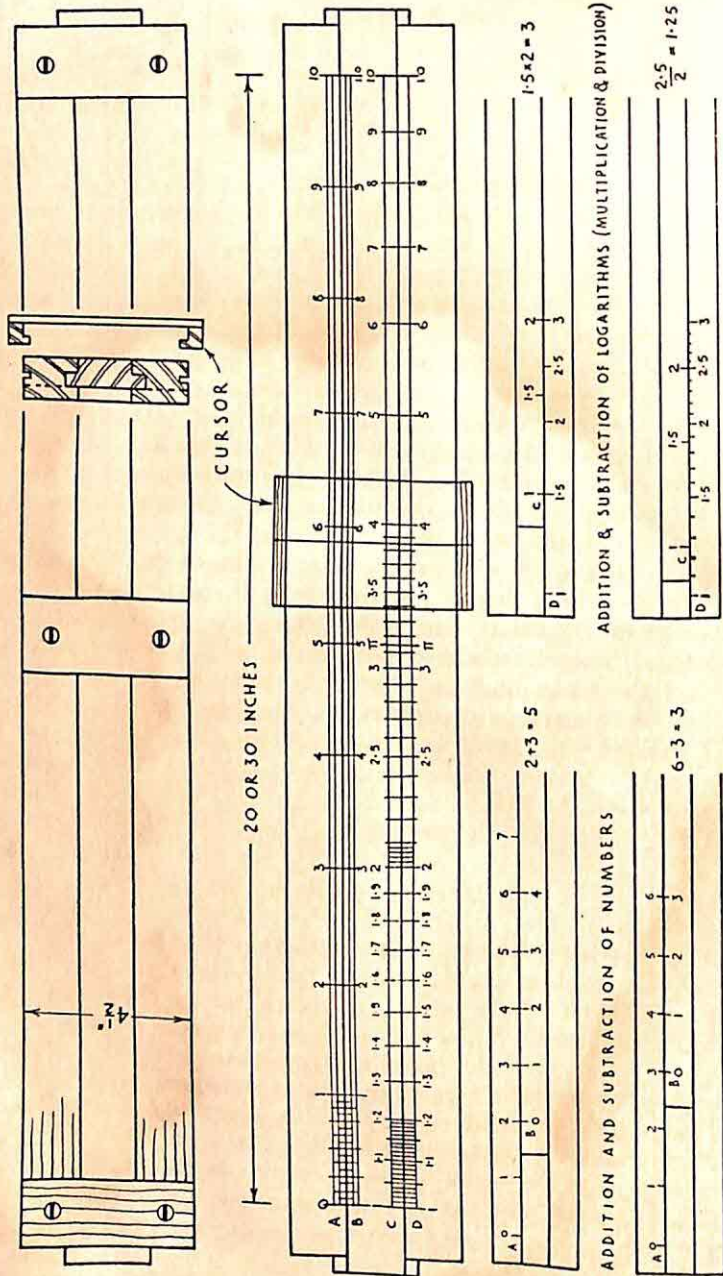


FIG. 44. DEMONSTRATION SLIDE RULE

These operations may be checked as follows—

$$10^2 \times 10^3 = 10 \times 10 \times 10 \times 10 \times 10 = 100,000$$

$$10^7 \div 10^3 = \frac{10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10}{10 \times 10 \times 10} = 10,000$$

Logarithms of numbers which lie between whole powers of ten are found in logarithm tables. E.g., the logarithm of 125 is 2.0969.

(2) Numbers (including fractions) may be added or subtracted visually by using two graduated rules edge to edge.

(3) Now since multiplication and division of numbers is performed by addition and subtraction of their *logarithms*, if logarithms be marked off to a suitable scale, the operations can be performed *visually*.

Further, if instead of logarithms the number itself is marked on the scales, the whole operation is done without the need for consulting logarithm tables.

Slide rules are usually made 5 in., 10 in. or 20 in. in length; greater accuracy being possible with increased length. For class demonstration purposes 20 in. or 30 in. should be suitable. Therefore, since the logarithm of 1 is 0 and that of 10 is 1 the scale must be twenty or thirty times full size.

The next stage is to prepare a table from which to work.

Number	Log	Scale	Measurement	Mark
1.0	0	$\times 30$	0	1
1.1	0.0414	$\times 30$	1.242	1.1
1.2	0.0792	$\times 30$	2.376	1.2
and so on, up to				
10.0	1.0	$\times 30$	30	10

The wooden portion of the slide rule (Fig. 44) is in three parts, the middle portion being two-thirds the thickness of the outer parts; this permits of cleats joining the outer parts behind the slide. When this part is completed satisfactorily, drawing paper should be glued (preferably with cold-water casein glue) over the face of stock and slide and put separately between clamps until dry. The drawing paper is trimmed carefully and the parts assembled.

The graduation must be done very carefully with Indian ink using a try-square and drafting pen. Figures may be done with a poster pen. To fix the graduations, thin size

or gum should be sprayed on and, when dry, a good quality church oak varnish brushed over them.

The cursor should be of "Perspex" $\frac{1}{8}$ in. thick, glued or screwed to rebated fillets, with a fine line scored perfectly square across the middle. As a refinement a shallow recess in one of the fillets may house a piece of clock spring to prevent excessive play between the cursor and the scales.

SECTION II

WOODWORKING TOOLS AND THEIR USES

IN this chapter general information concerning tools and their uses is collected and arranged for reference, as required, at any stage of study.

It should be understood that the study of tools can be extended much beyond the treatment given here, and would be so extended in senior and advanced instruction in a craft course planned for apprentices in the building industry. The mechanics of tool design is both fascinating and educational and many teachers may include at least an approach to the subject in their scheme of lessons. In the sections on (a) braces, (b) pincers, and (c) planes, the subject is introduced.

It should be noted that there are many variations in both the form and the size of several ordinary tools; those illustrated are typical of the ordinary forms.

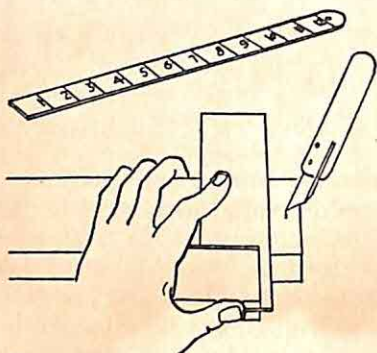
The various tools are not necessarily taken in the order of use, as introduced to students through graded exercises. They are considered in groups, e.g. saws and planes. In selecting classwork, therefore, the teacher should guide the student as to the order of reading and sketching which fits in best with his own particular course of study.

MEASURING AND MARKING TOOLS

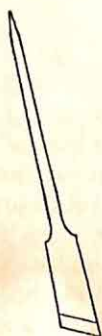
Accurate measuring and marking is as essential on the actual work as on the drawing. Consequently, the sharpness of the pencil and the *marking* or *scribing knife* are an important first requirement in marking out a piece of work. Fig. 45 shows the measuring and marking tools.

Woodworkers usually use a four-fold *box-wood rule* 2 ft or 3 ft in length for measuring, but a *steel rule* is just as effective provided its divisions are in eighths and sixteenths. Smaller divisions are confusing. A difficulty in using a wooden rule is caused by its thick edge. Unless the work is viewed squarely, inaccuracy results when marking off dimensions.

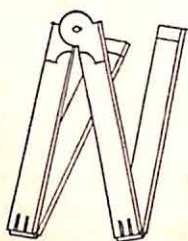
As right angles are most often in demand the *try-square* (which has a thick stock and a thin blade) is set permanently at 90° for drawing lines square across the wood. The adjustable



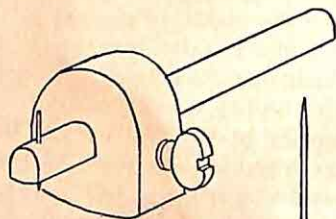
PLACE THE MARKING KNIFE
ON THE POINT, AND SLIDE
THE TRY SQUARE ALONG TO IT



SCRIBING KNIFE



2 FT. FOUR-FOLD
BOXWOOD RULE



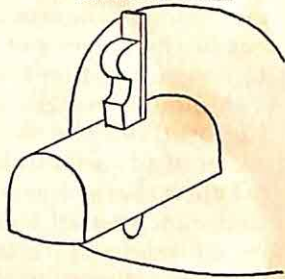
MARKING GAUGE FITTED
FOR LEFT-HAND GAUGING



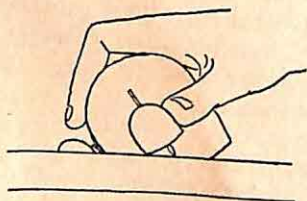
MARKING
POINT



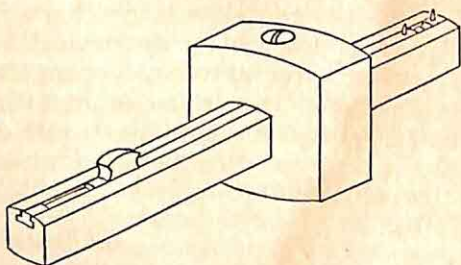
CUTTING
KNIFE



CUTTING GAUGE



GAUGING RIGHT-HANDED
THE GAUGE MUST ALWAYS
BE PUSHED, WITH THE
MARKING POINT TRAILING



ROSEWOOD MORTISE GAUGE
POINT ADJUSTED WITH FINGER SLIDE
SET SCREW TIGHTENS SLIDE & STOCK

FIG. 45. MEASURING AND MARKING TOOLS

bevel is used for other angles. The blades of both tools are usually of mild steel, which is comparatively soft; as marking knives are made from harder carbon steel to hold a keen edge, the guiding edges are liable to wear and need truing up by a person skilled in the use of metal files. Squares and gauges should always be held against the face side or face edge.

A *gauge* consists of a small stem sliding in a stock. The stem carries one or more steel marking points or a cutting knife; the distance of the stock from the point or cutter can be adjusted for any "gauge" (measure) and the position secured by a fixing screw—either a boxwood thumbscrew or a steel screw, in the case of a mortise gauge. The *single* or *marking gauge* has one marking point; the *mortise gauge* has two, one fixed and the other attached to a metal slider; the *cutting gauge* has a cutting knife held in position by a wedge so that its projection may be varied for the depth of the cut.

All these gauges are used for lines parallel to the long edges of the wood; they are in constant use and are both economical and efficient when their use has been mastered.

When using a gauge allow the point(s) to trail behind. If they are pushed vertically, a very thick line results with a strong tendency to follow the line of the grain instead of the desired straight line parallel to the face edge or face side.

The mortise gauge allows the width of a mortise to be gauged in one operation; the one illustrated is the simplest of its kind. One point is attached to a brass slider for adjustment. A more elaborate type has a screw adjustment; another type still, has two stems which slide through the stock, and a V-edged wheel on each which makes the marks.

Cutting gauges are more often used in cabinet making than joinery, but are useful for cutting half-way through from either side of thin wood or three-ply, which may then be snapped in the fingers.

CHISELS

The blades of chisels and planes are manufactured from carbon steel, also known as cast steel or tool steel. The 1-1.5 per cent of carbon in the steel enables it to be hardened and tempered.

Hardening of carbon steel is accomplished by quenching the red hot metal in cold water. *Tempering* means drawing

away some of this hardness, for if the metal becomes too hard it will be brittle and snap readily. It must be tempered so that it is neither too brittle nor too soft; the latter condition would mean that the fine sharp edge would bend over. The tempering is done by reheating (after hardening) to the required temperature. When each tool is done separately by a craftsman, it is possible to judge the temperature by the colour of the film of oxide which appears on the bright metal surface. When a piece of metal is put in a flame, various colours appear, first pale yellow, then orange, red, purple, and blue. With care a final oxide appears which is the same colour as the metal, then it turns blue again and purple and so on to the glowing red.

The skill in tempering is to catch the metal at the right colour. The tool must of course be heated equally all over, usually in a "muffle." Woodworkers' chisels are tempered to yellow or orange temper.

Three types of chisel are shown in Fig. 46; the *firmer chisel* for general use, the *paring chisel* for hand paring only (usually lighter, longer and with bevelled edges), and the *mortise chisel* for dividing mortises.

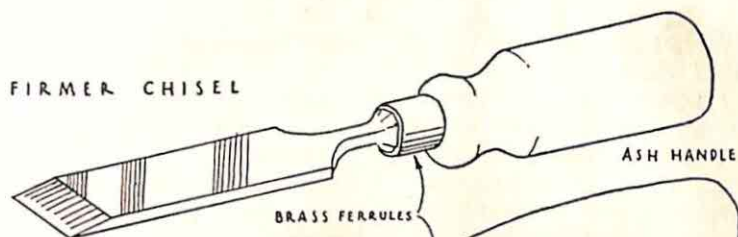
The handle of a chisel is usually of box, ash or beech; a short length of brass tube, called a ferrule, is used on most chisels to prevent the handle splitting when the tapered tang is tapped home. An exception is the mortise chisel which is used with the mallet and has a leather washer at the shoulder to absorb the hard shocks of the mallet blows. The sash mortise chisel (not shown) is something between a firmer and an ordinary mortise chisel and is used for lighter work.

Gouges are chisels with curved sections, and are of two main kinds, *scribing* (ground inside) and *firmer* (ground outside). The joiner most often needs the scribing gouge, as will be seen later. For certain purposes gouges may be bent in their length as shown in Fig. 46.

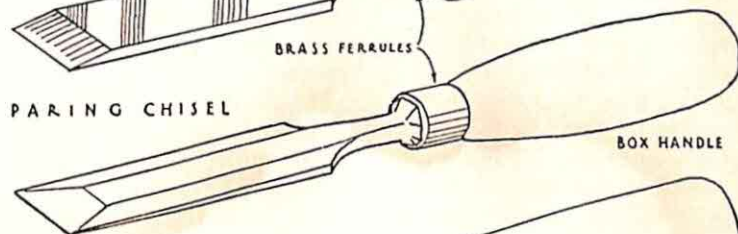
When necessary, a mallet is used for driving chisels. It is fatal to the chisel handle to use a hammer. There is, however, a type of chisel made for rougher kinds of work, which is adapted for use with a hammer; a steel band round the top of handle prevents the wood from splitting.

Refixing Handles. Occasionally a handle works loose and needs refixing. To do this, half-fill the hole with resin, gently heat the tang of the blade, and push it in.

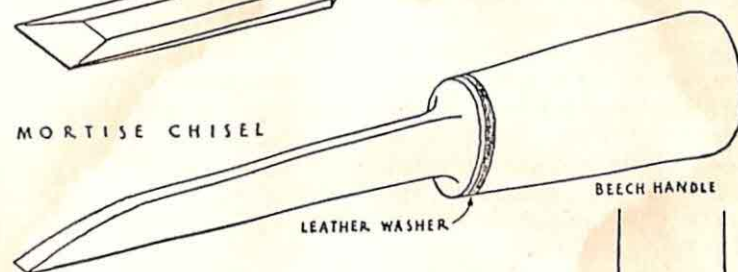
FIRMER CHISEL



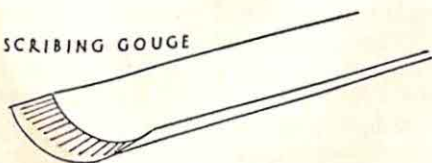
PARING CHISEL



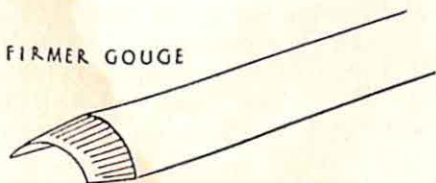
MORTISE CHISEL



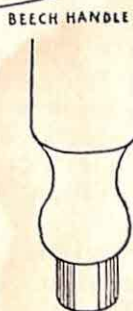
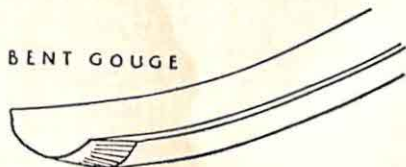
SCRIBING GOUGE



FIRMER GOUGE



BENT GOUGE



TAPERED TANG
FOR HOLDING
BLADE TO HANDLE



FIG. 46. CHISELS AND GOUGES

Use of Chisels. Two very important points must be borne in mind when using chisels—

(1) *Take care of the hands.* Remember to keep both hands behind the cutting edge. More injuries result from misuse of chisels than from all the other tools together.

(2) *Take care of the chisels.* A blunt chisel is of little use for cutting wood, although in this condition it is still quite effective in inflicting injuries on the user.

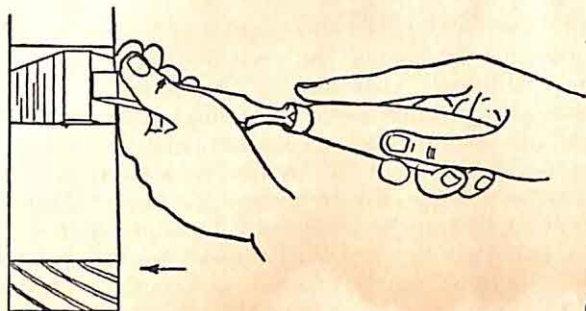
A beginner is not usually expected to sharpen chisels and therefore does not appreciate how easily and how often the edges become dull. Since the edges are dulled by ordinary use, it follows that contact with other objects, not to mention being jumbled about with other tools on the bench, has the same effect. A chisel must be put down carefully, preferably with the grinding bevel downwards, in the well of the bench to prevent it rolling off. Many woodworkers keep gouge and chisel blades in a sheath when not in actual use.

Paring. When using hand pressure on the chisel, two positions are usually adopted—(a) that for horizontal paring, usually across the grain; and (b) that for vertical paring (see Fig. 47). In either case the left hand restrains and guides the tool while the right hand supplies the pressure. Never press with both hands, or there will be no control on the tool. For extra pressure when paring vertically, use the shoulder.

Mortising. Start at the middle of the mortise and take out a wedge-shaped piece. Then work towards the ends leaving a little to be taken out at the last operation. Work half-way from each side; the core may be cleared by using a smaller chisel or by "drifting" with a piece of wood smaller than the mortise to avoid splitting.

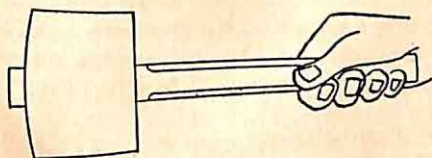
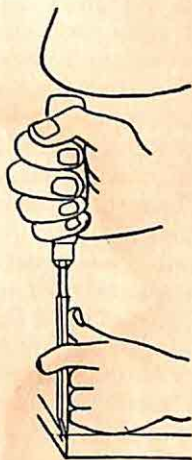
Using Mallets and Hammers. These tools must not be "choked." Many beginners hold them around the neck and dab the head on the object to be struck. The handle is made a good length so that the weight on the end can travel through a wide arc, its own weight and speed supplying the necessary force. Therefore hold the handle near the end (Fig. 47), keep it and the forearm in a straight line, and use the elbow as the centre of swing.

If you think of a navvy swinging a sledge hammer you will see how much more effective this is than dabbing.

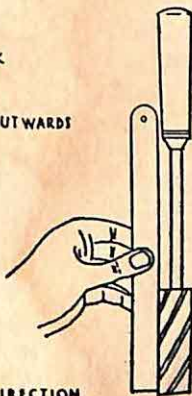
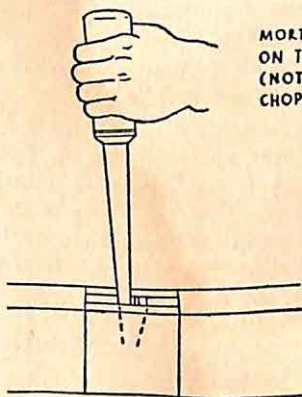


CHISELLING ACROSS THE GRAIN -
WORK FROM BOTH SIDES, FINISHING
THE BEST WAY (SHOWN BY ARROW)

VERTICAL PARING -
USE THE SHOULDER IF
ADDITIONAL PRESSURE
IS REQUIRED.



MORTISING - REST THE WORK
ON THE BENCH OR A STOOL
(NOT IN THE VICE)
CHOP OUT FROM THE MIDDLE OUTWARDS



TEST FOR DIRECTION

FIG. 47. USE OF CHISELS

THE MALLET

Fig. 48 shows a mallet which may be used for two purposes. The first is for driving wooden handled tools, i.e. chisels, when mortising or doing other heavy chopping out. For this purpose it must be swung through an arc of which the centre is the elbow, to enable the elbow to be kept at a comfortable working height, therefore, the impact faces of the mallet should be along lines joining at the elbow; hence the tapered shape.

Secondly, the mallet is needed to drive heavy timbers when assembling framed material, the joints having previously been fitted hand tight; for this purpose a smooth slightly rounded face is necessary if the material is not to be bruised. It would be rather uncomfortable for the knuckles if these faces were tapered, so they are left parallel. It is essential that the sloping surfaces only are used for tool driving, and the parallel faces kept smooth for the job of "bumping up."

To Make a Mallet. Fig. 48 is fully dimensioned so that the mallet may be made as an exercise. Having selected a piece of sound heavy red or white beech for the head and a piece of straight grained beech or ash for the handle, plane up true and mark out as shown.

One $\frac{3}{4}$ in. or two $\frac{5}{8}$ in. holes are bored half-way from each side, to save heavy chopping out, and the mortise carefully cleared, keeping the inside clean and true.

The handle is designed to overcome the tendency (a) for the head to fly off and (b) for the mallet as a whole to fly out of the hand. To overcome (a) the handle is made tapered in one direction so that the head wedges farther on by use; and to overcome (b) the handle is rounded to within about 1 in. of the end, leaving a rectangular lump.

When making the handle leave it $\frac{1}{16}$ in. wide on the tapered side and gradually ease it with fine plane shavings until, by bumping the handle on the bench, the head travels to within 1 in. of the top. Shape up the handle by first chamfering with a spokeshave, as shown in the drawing, and then rounding off, finishing with glasspaper.

BORING TOOLS

Bits, Drills and Braces, (Fig. 49). Woodcutting bits are of three main kinds—

(a) For boring holes accurate in size and position.

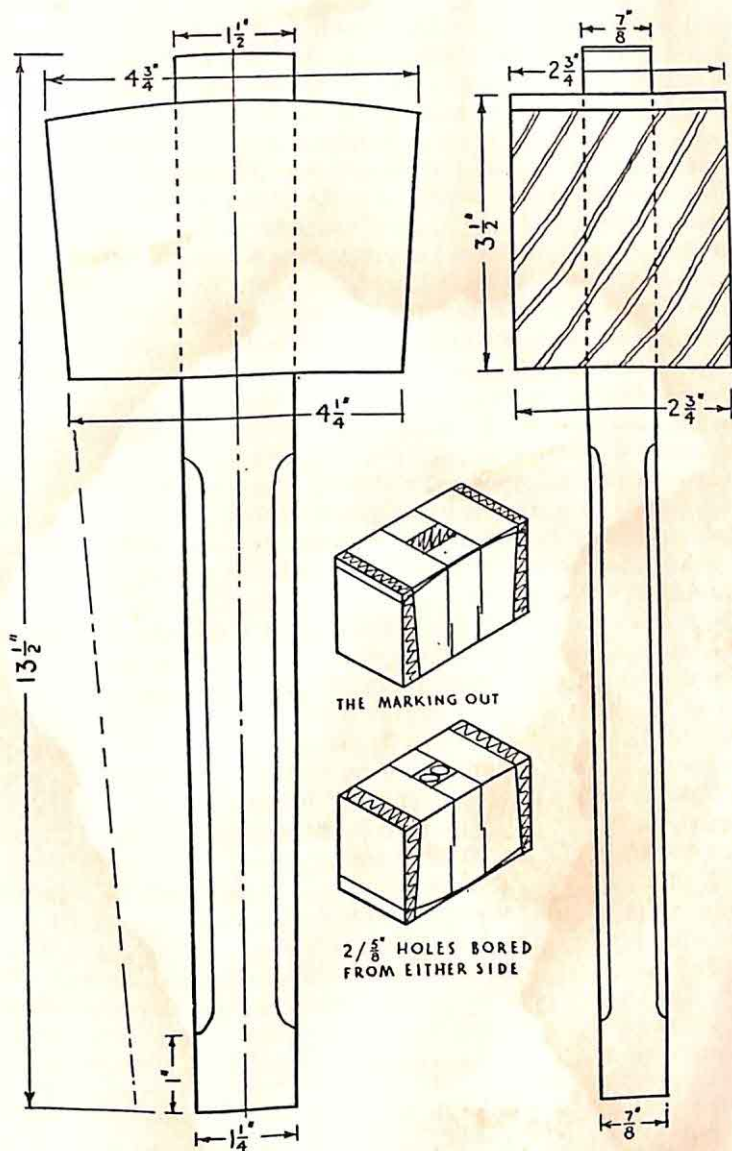


FIG. 48. THE Mallet

(b) For boring holes which need not be quite so accurately placed or of very precise diameter, e.g. holes of screws.

(c) For performing special operations, e.g. turning screws, countersinking and reaming.

Of the first group, the *centre bit* is the most common and has three essential features; a central pin to fix the exact position of the hole and to provide a point about which the cutting portions can revolve, a knife edge to incise the outer edge of the hole, and a chisel edge to remove the wood. Pressure is required to make this bit work.

The *twist* or *auger bit* is designed to pull itself through the wood. The central pin is screw-threaded for this purpose. Two knives and two cutters enable the bit to cut quickly and accurately, and the waste is raised to the surface by the large thread which forms the body of the bit. This type has largely superseded centre bits (except for shallow holes), and the best of the kind are made by Irwin (illustrated) and Russell Jennings, the latter being suited to hardwood on account of its slower rate of cutting (determined by the pitch of the screw).

Centre and twist bits both leave the bottom of a "blind" hole unfinished and the central pin makes a deep penetration within the hole, which may prove inconvenient if a thin part is to be left, e.g. when removing waste for an oilstone box. The *Forstner bit* has a circumferential knife edge only slightly in advance of the cross cutters, designed to overcome this difficulty.

For holes above 1 in. diameter, some woodworkers carry an *adjustable bit* so as to save carrying additional weight. A centre bit to bore a $1\frac{1}{4}$ in. hole for fitting cylinder type latches is, however, sufficient for most craftsmen.

A *shell bit* (of gouge-like form) is adapted for boring screw-holes quickly, but having no central pin can be positioned only approximately.

Countersink bits may be of the *shell* or *rose* varieties (see Fig. 49). The *screwdriver bit* is useful where speed of insertion or great turning power is required. Given a 10 in. brace and a $\frac{5}{16}$ in. edge to the bit, the turning force at the handle is magnified sixteen times at the driving end. Thus a turning force of 10 lb applied at the handle becomes 160 lb on the screw-head.

Morse drills are very convenient for making screw-holes, especially when used with a *wheel brace*; these are really

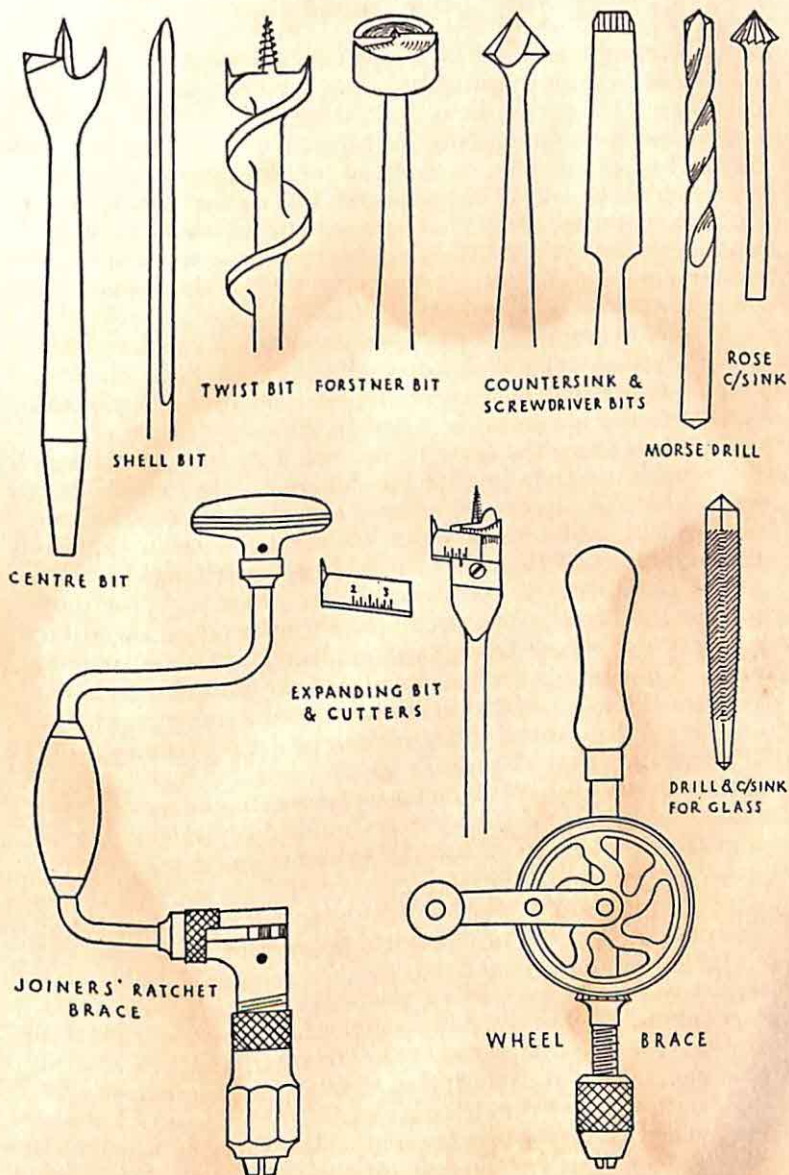


FIG. 49. BITS, DRILLS AND BRACES

metal-working tools and consequently adapted for drilling a variety of materials on which normal woodworking bits would be spoiled.

Reamers (not illustrated) are tapered bits shaped like shell bits and used for enlarging holes.

DRILLING GLASS. The carpenter and joiner has to be an adaptable craftsman able to cope with a variety of jobs. Mirrors, plate glass and glazed tiles are not woodwork, but the woodworker often has to cope with the fixing of materials other than wood.

A saw file ground to a three-cornered point can be put in a joiner's brace and used to drill plate glass. If the thick end is similarly ground, it will serve for countersinking. Turpentine is used to lubricate the cut.

Joiner's Brace. A *ratchet* type is most useful for turning bits and drills of all kinds, being adaptable (a) for working in confined situations, and (b) for when the cut is particularly heavy and it is desirable to pull the handle through a quarter-turn only.

The chuck (which holds the bits) has two jaws, V-grooved to grip the square shanks of bits; they are also effective in gripping round and triangular shanks. The size of a joiner's brace is determined by the diameter of the circle through which the centre line of the handle swings. Sizes vary between 6 in. and 12 in. the most useful size being 10 in.

Wheel Brace. With these the size is measured by the capacity of the chuck. Thus a $\frac{1}{4}$ in. brace will accommodate $\frac{1}{4}$ in. parallel shank morse drills. This size is quite large enough for the woodworker's purpose.

TOOLS FOR DRIVING NAILS AND SCREWS

These are illustrated in Fig. 50.

Hammers. The joiner's hammer is invariably one of the cross pane types, either Warrington or London pattern; the cross pane being useful for starting small nails when working at the bench. The carpenter more often favours the claw hammer because it saves time and trouble to have a combined tool, particularly when climbing about. Ball-pane hammers are not, strictly speaking, woodworkers' tools, but they come in useful for burring the ends of rivets. The driving face of a hammer must be made slightly rounded and kept polished;

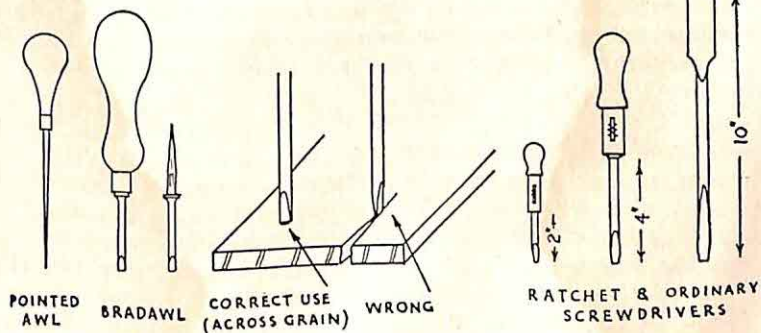
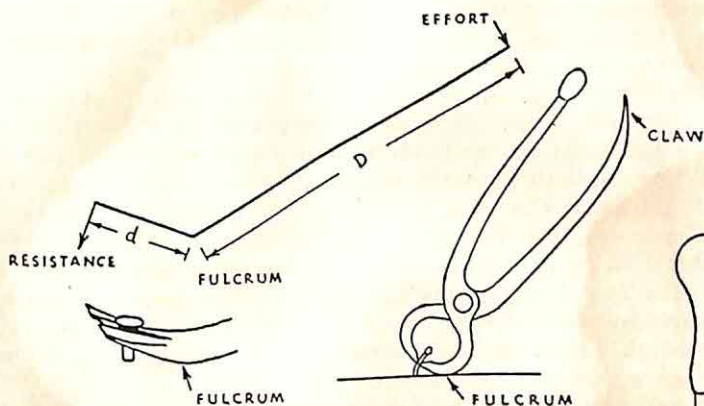
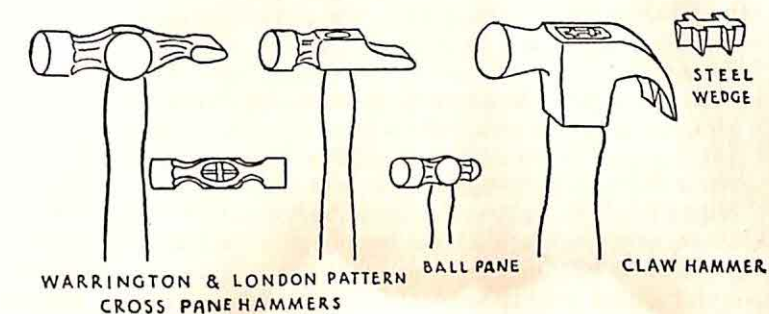


FIG. 50. TOOLS FOR DRIVING AND REMOVING NAILS AND SCREWS

strange as it may seem, a flat or a dirty face causes nails to bend. Another common cause of faulty nail-driving lies in gripping the hammer too near the head. The handle should always be gripped at the end, and handle and forearm lie in a straight line, using the elbow as the pivot. A shorter radius of swing (say from the wrist) gives a quicker curve, with greater liability to a glancing blow on the nail head.

Pincers. These should be used much in the way that a claw is used, that is as a lever, rolling the head along the wood once the nail has been securely gripped. Seldom is it necessary to pull directly outwards. In cases where a rolling action would injure the wood surface, a thin flat piece of wood or metal may be put between. Pincers and other nail-pulling devices provide an interesting study in leverage. The resistance provided by the nail at one end is overcome by the effort at the other, the whole pivoting about the fulcrum. Using the equation $E \times D = R \times d$, the holding power of a small nail may be estimated by reproducing against a spring balance, the effort used in nail-pulling.

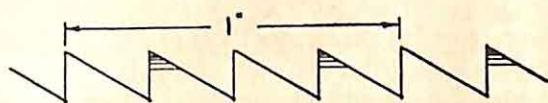
Awls are made both pointed and chisel-edged. The former are useful for exploring plastered walls and ceilings for firm fixings. The chisel-edged type are known as bradawls, and are used preparatory to driving nails or screws in order to obviate splitting thin materials. It is essential that the fibres of the wood are *cut* by placing the edge across the grain.

Screwdrivers. Woodworkers may need three or more of these; a large one for plane iron and other large screws, a medium one for general use, and a small one. The two smaller might with advantage be of the ratchet type, for speed of action. There is a type of screwdriver utilizing the Archimedian spiral for extra rapid action; these are expensive and not usually found in the craftsman's kit—a screwdriver bit for use in conjunction with a brace being more popular.

SAWS

Saws are of two main kinds, those used for sawing along the grain of the wood, called rip-saws; and those for sawing across the grain, called crosscuts. A crosscut saw may be used *along* the grain, but rip-saws should never be used *across* the grain.

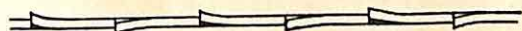
A rip-saw has teeth formed in the shape of numerous chisel edges (Fig. 51) and by analogy with the use of chisels it is



ENLARGED VIEW OF RIP TEETH

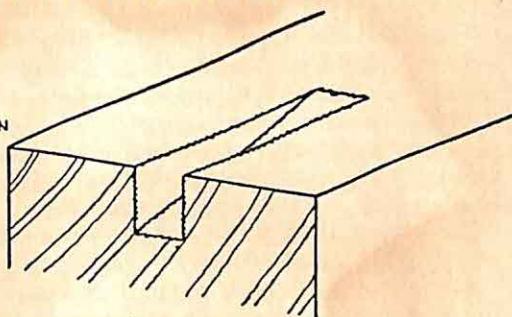


END VIEW



RIP SAW — FOR USE ALONG THE GRAIN OF THE WOOD
 $3\frac{1}{2}$ TO 7 POINTS TO THE INCH

CHISEL-LIKE ACTION
 OF RIPPING



ENLARGED VIEW OF CROSSCUT TEETH



END VIEW



CROSSCUT SAW — FOR USE ACROSS THE GRAIN
 5 TO 11 POINTS TO THE INCH

INCISING ACTION
 OF CROSSCUTTING

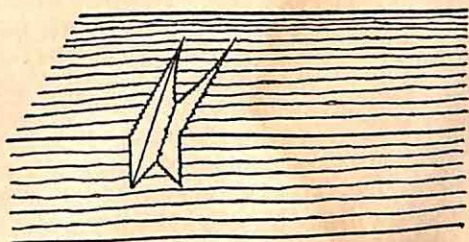


FIG. 51. SAW TEETH FOR RIPPING AND CROSSCUTTING

known that a very coarse shaving can be taken off with the grain. On the other hand, if an attempt be made to drive a chisel across the grain, the fibres of the wood on either side cling tenaciously and prevent any effective work being done. The fibres must always be parted first on both sides of the cut, then the wood between is readily removed. In the case of a saw the side cuts are so close that the wood between crumbles away; one can now imagine the consequences which would result from trying to use a rip saw for crosscutting.

The crosscut teeth have to be designed as knife points which cut through the fibres on either side, allowing the tiny lengths of fibre between to crumble away as sawdust.

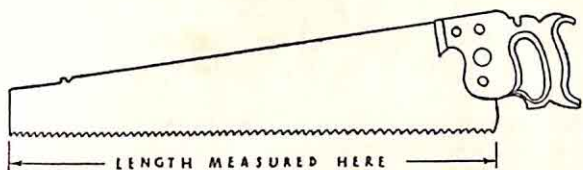
The diagrams showing the enlarged views of saw teeth are simplified for purposes of drawing. Note that the rip teeth are shown as right-angled triangles while the crosscut teeth are equilateral; in practice rip teeth actually lean back a little from the angle shown, while the crosscut teeth lean forward a little. This makes the rip saw work more smoothly and enables the crosscut to be used better for ripping, and if required the actual angle will vary considerably with the kind of wood to be cut and the preference of the user.

The amount the tooth leans is known as the "hook." The maximum hook occurs when the leading side is upright and the minimum when it has an equal slope on either side. The more hook, the fiercer and quicker cutting the saw, and vice versa. Another factor which influences speed and coarseness of cutting, is the number of points to the inch—the smaller the teeth, the finer the cut.

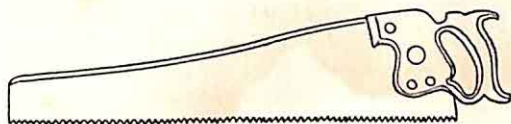
Set. The teeth are bent alternately to one side and the other as viewed from the top. This is done so as to make the cut wider than the thickness of the blade, and thus ensure that it clears the sides of the cut as it passes through. Again, the amount of set depends upon the type of work being done. Green or damp timber will require that the teeth have plenty of set, whilst dry wood requires less.

Saws for various purposes are shown in Fig. 52.

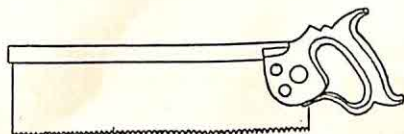
Handsaws. Included in this group are both rip and crosscut saws. These vary in length, but are usually from 22 in. to 28 in., although obtainable up to 32 in. Handsaws 16 in. to 22 in. in length and having between 10 and 12 points to the inch are often called *panel* saws, and are used chiefly on good



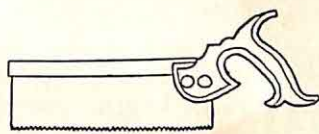
HANDSAW,
RIP OR
CROSSCUT
(STRAIGHTBACK)



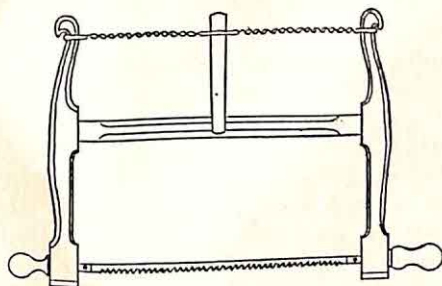
PANEL SAW
FINE CROSSCUT
(SKEWBACK)



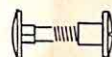
TENON SAW



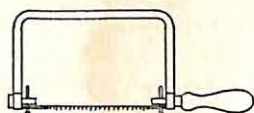
DOVETAIL SAW



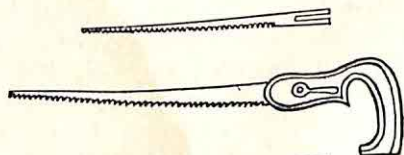
BOW SAW (WOOD FRAME)



SAW RIVET



COPING SAW (METAL FRAME)



NEST OF COMPASS SAWS



PAD SAW (WOOD HANDLE)



ADAPTABLE METAL HANDLE

FIG. 52. TYPES OF SAW

joinery work. Sizes recommended for general use are—rip 26 in., 4½ points; crosscut 24 in., 8 points; panel 20 in., 11 points.

Handsaws are made either with straight backs (the English type) or with curved backs, known as "skewbacks"; this type originated in America, and is supposed to be quicker and easier cutting, due to the thinner back edge (giving more clearance) and the low-set handle which gives a more direct pressure. The writer has found no advantage in the skewback type, but has often used the straight back of the English type for an emergency straight-edge.

Ripping and Crosscutting (Fig. 53). When using handsaws the aim should be to grip or firmly support the plank, using the free hand to grip the piece coming off. A long steady stroke using the whole length of the saw is the correct method. No excessive pressure should be used, nor will it be required if the saws are kept properly sharpened. A smear of oil on each side of the saw makes for ease of cutting, and when ripping it is desirable to keep the cut open by means of a wooden wedge placed in the cut behind the saw.

When the user is sufficiently skilled with hand saws, the tenon saw can be reserved for the finer work; and such operations as sawing tenons along the grain on wide members may be accurately done with the rip saw.

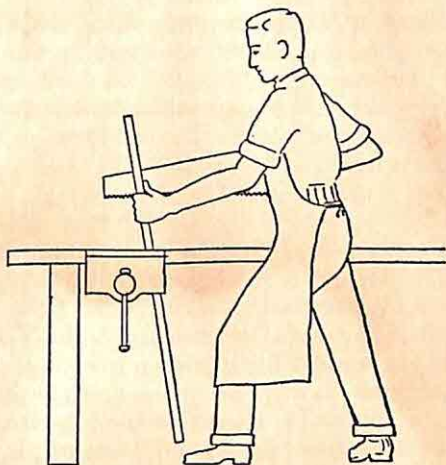
Tenon Saws. The tenon saw is a general purpose saw having a parallel blade and a stiffening piece on the back. Usually the larger sizes have closed handles, while the smaller are open. The smaller ones are known as *dovetail saws*. A round handle is also occasionally fitted on very small dovetail saws. Recommended sizes: tenon 14 in., 12 points; dovetail (open handle) 10 in., 16 points.

Saws for Curves. To negotiate curves the blade must be narrow; this makes it weak, so the more reliable tools have some method of keeping the blade taut. The *bow saw* has a wooden framework, the two outer portions pivoting on a middle rail, and tension is applied by a tourniquet and hemp twine. The *coping saw* has a metal frame which is made so that the opening is too wide for the blade and must be pulled in to allow the pins at either end of the blade to be forced into position. A screw inside the handle applies further tension.

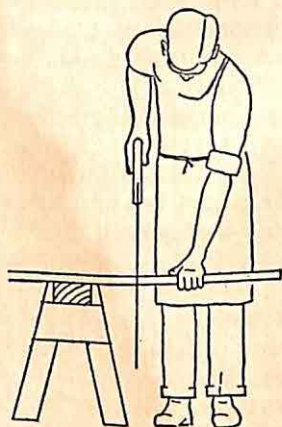
Keyhole or pad saws, also *compass saws*, are used in places



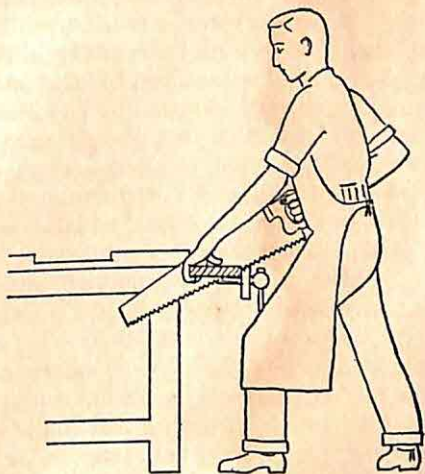
RIPPING A BOARD - MOVE THE
STOOLS AS THE CUT PROCEEDS
TO SUPPORT WORK NEAR THE SAW



RIPPING WITH THE WORK HELD IN THE VICE



CROSSCUTTING - SUPPORT THE PIECE
COMING OFF



CROSSCUTTING WITH THE WORK HELD IN THE VICE.
ALTERNATIVELY THE WORK MAY BE RESTED IN
THE WELL OF THE BENCH.

FIG. 53. OPERATIONS OF RIPPING AND CROSSCUTTING

where it would be impossible for a frame-saw to pass. To avoid bending the blade great care is needed in use.

The metal pad handle is a most useful item for the carpenter's kit, as it takes pad saw blades, warding files and hacksaw blades; the latter are most useful when an unexpected nail is encountered.

PLANES

The design of planes of all kinds is a most interesting study. The forerunner of the plane was the adze, an implement resembling an axe but with the cutting edge at right angles to the handle. With this tool the carpenter standing on the horizontal plank, was able to swing the adze and chip off short pieces which left an irregular surface. To obtain a continuous shaving and a truer surface a cutting blade was mounted in a piece of wood, and so a form of plane was established. With improvements in shape and variations in size and purpose our present planes were developed.

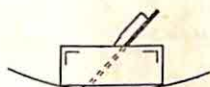
Planes for Various Purposes. (Figs. 55 and 56.) The longer the plane, the straighter it is obliged to plane, since an arc taken through both ends of the bottom and the cutting edge is of larger radius (see top of Fig. 54). Thus a *trying plane* is a comparatively long one (22 in.) and is used for obtaining very true surfaces. The wider a plane, the flatter it is obliged to make the surface, since the curve again depends upon outer edges and centre of cutting edge; thus a trying plane usually has a cutting edge $2\frac{1}{2}$ in. wide.

General purpose *jack* and *smoothing planes* are made with 2 in. to $2\frac{1}{4}$ in. cutting blades, the former being 17 in. and the latter 8 in. long.

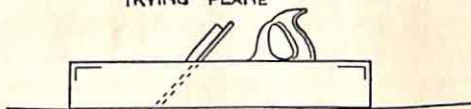
A very useful plane for quick rough work is the *Bismarck plane* (Fig. 55), which is short and narrow, with a $1\frac{1}{2}$ in. curved cutting edge, no back iron, and a wide mouth. Shavings up to $\frac{1}{8}$ in. thick can be taken off; but, because of the rapid tearing action of the plane, it is advisable to traverse the surface of the wood diagonally.

Wooden Planes. These are best made of red or white beech. Carefully selected seasoned timber is used so as to minimize subsequent movement due to variations in the humidity of the atmosphere; but as this movement cannot be entirely eliminated, it must be allowed for in the design of the plane. Wood

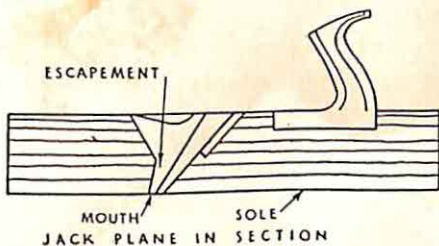
SMOOTHING PLANE



TRYING PLANE



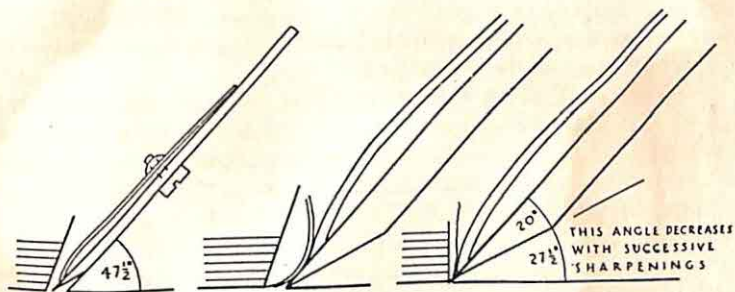
THE LENGTH OF A PLANE DETERMINES THE AMOUNT IT WILL PLANE "HOLLOW"
EXAGGERATED CURVE PASSING THROUGH ENDS OF PLANE AND CUTTING EDGE



GOOD



BAD



CUTTING & BACK 'IRONS' COARSE WORKING & FINE WORKING

SMOOTHING PLANE FITTED WITH STEEL SHOE
AND 'CLOSED TOAT' HANDLE

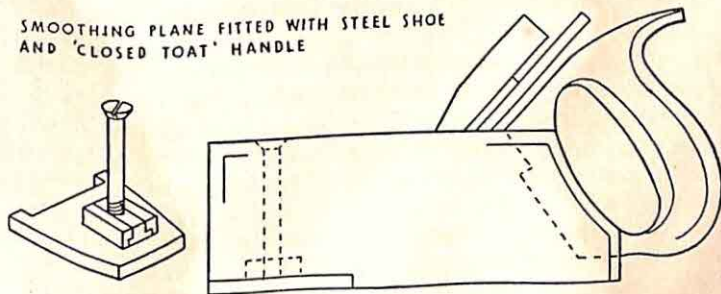


FIG. 54. PLANES

MOULDINGS

REBATE

CHAMFER

OVOLO

CAVETTO

BEAD

CYMA RECTA

CYMA REVERSA

DEPTH
STOP

VERTICAL
LINE

'STICKING' AN
OVOLO MOULDING

SINGLE 'IRON'

REBATE PLANE

"BISMARK" PLANE

FRICTION EXPERIMENT

GRIP WHEN
REMOVING WEDGES

UNSETTING SMOOTH

AND JACK OR TRY PLANES

SETTING PLANES

FIG. 55. PLANES (CONTINUED)

shrinks and swells according to the condition of the atmosphere the greatest movement taking place along the line of the annual rings. It will be seen that this movement does the least harm when the rings lay across the plane. This way, too, the sole of the plane will have the most even and, consequently, best wearing surface.

Jack and trying planes have satisfactory handles; but many woodworkers, disliking the grip of the smoothing plane, either make or purchase a suitable handle, e.g. a jack plane handle of the closed type and fix it in (Fig. 54). The steel front piece shown is a desirable feature for a smoothing plane which is to be used on hardwood. (Many craftsmen have two smoothing planes—one kept for general purposes and the other for the hardwood.) The steel shoe prevents the sole from wearing down, thus obviating the trouble occasioned by the mouth becoming wider.

Striking buttons, where used, are of boxwood with the end grain uppermost. This is a feature which the craftsman would scorn to use, as his hammer blows are so deftly placed as to polish the surface rather than damage it. Buttons are useful for the amateur, or for thoughtless people who need a target to remind them of the right place to strike a plane. Planes reflect the character of the user; a plane which carries hammer dents, particularly if they are in the wrong places, is a permanent reproach. The true craftsman takes a pride in his tools, and he is repaid by a glossy cheerful-looking plane. Remember that one unkind crack will scar a tool for life; it is a good idea, therefore, to practise placing the hammer blows on a piece of hardwood without damaging the surface. Another good plan is to give wooden planes a frequent rub over with linseed oil; this, together with handling during use, develops surfaces rivalling the finest french polishing.

Setting. The setting (cutting adjustment) of planes is most important. Fig. 52 shows the method of holding and striking to release the irons and position the cutter.

CUTTING ACTION (Fig. 54). The efficient working of planes under various conditions depends on several factors—

- (1) The angle at which the blade is set in the body of the plane fixes the *cutting angle*. In the case of planes with a back iron these are $47\frac{1}{2}^{\circ}$ and $42\frac{1}{2}^{\circ}$ respectively.
- (2) Suppose the cutting blade to be held at an angle of

$47\frac{1}{2}^{\circ}$ while sharpening it will be clear that it would merely slide over the wood; a *back clearance* is therefore required. This varies with the sharpening angle; gradually becoming smaller as successive sharpenings cause the contained angle to increase. In this latter condition a stiffer edge results; which is quite useful on hardwood, since a fine thin edge tends to spring and yield, causing the plane iron to vibrate and "chatter."

(3) The space between the cutting edge and the body of the plane has an important bearing on its working qualities. Coarse working planes, e.g. jack planes, need at least $\frac{1}{8}$ in. gap; so that a thick shaving can bend easily through the opening. This arrangement, however, does permit tearing up against the grain—no disadvantage with mild working wood, since the wood may be planed the best way of the grain. Some hardwoods have interlocking grain which tears either way. In this case the gap may need to be as small as $\frac{1}{16}$ in.; in this case not only will thick torn portions not pass, but the material is held down until actually cut by the cutting edge.

(4) The back iron is set $\frac{1}{8}$ in. to $\frac{1}{16}$ in. from the cutting edge, depending upon the coarseness or fineness of the work. A thick shaving cannot easily pass the back iron when the latter is set too near the cutting edge. Bearing this in mind, the nearer the back iron can be set to the cutting edge the better, since the cutting edge must of necessity be thin but ought at the same time to be sustained against the pressure of cutting.

STEEL AND WOODEN PLANES COMPARED. Steel planes have many advantages over wooden ones; e.g. instant adjustment for depth of cut, and squareness of blade, permanently true sole, easy adjustment of mouth, and a thin cutting blade which seldom requires grinding.

Why then are wooden planes still widely used and why do some craftsmen prefer them for general work? One disadvantage is the thin blade; if a heavy cut is attempted the lack of weight causes vibration and chattering. Another point may be best investigated by means of an experiment.

The amount of friction between two surfaces sliding one over another depends upon—(1) the materials, (2) their condition (roughness or smoothness), (3) the pressure between the surfaces.

EXPERIMENT (see Fig. 55).

Aim. To determine the force necessary to overcome friction

caused by wood and steel planes sliding over wood, also the effect of lubricating the surfaces.

Apparatus. Three pieces of wood planed smooth (say deal, oak and mahogany), two wooden planes, two steel planes, pair of scales, pulley, string, weights, linseed oil.

Method. Place the sample of wood flat, and find the least horizontal force necessary to move the planes along at an even speed. Repeat for each sample. Repeat with oil smeared on the sole of the planes.

Readings. Set out your readings thus—

Expt. No.	Plane	Wood	Force (lb)	$\frac{\text{Force}}{\text{Weight of plane}}$
1	Wood smooth	Deal		
2	Steel smooth	Deal		
3	Wood jack	Deal		
4	Steel jack	Deal		

— and so on.

Conclusion. (This is for you to write.) The last column will give the proportional amount of horizontal force required to overcome friction between the particular pair of surfaces. Suppose one pair worked out to 0.3, then for that pair of surfaces we may multiply the weight of an object by 0.3 to determine the force necessary to overcome friction. Such a multiplier is also called a coefficient, thus 0.3 would be the "coefficient of friction" for that pair of materials.

The reader should now be in a better position to judge which planes will require most effort to push them over the wood. Some other points also arise; for instance, what is the effect of the additional pressure put on the plane by the user? Presumably this will be roughly constant given the same condition of cutting edge, but a blunt edge will need more persuasion to bite into the wood than a keen edge. One last thing: the oil used to lubricate the sole of a plane should be linseed oil, for ordinary lubricating oil impairs the surface for treatment by painting or polishing. Linseed oil goes well with wood being largely absorbed into the pores, but forms an undesirable sticky skin on steel which has to be scraped off.

SPECIAL PLANES

The Plough. This is a plane designed to make a groove at a parallel distance from the face. It is also used to start rebates

where required. A depth gauge on the plane is set before commencing work and comes into play when the groove is at the determined depth.

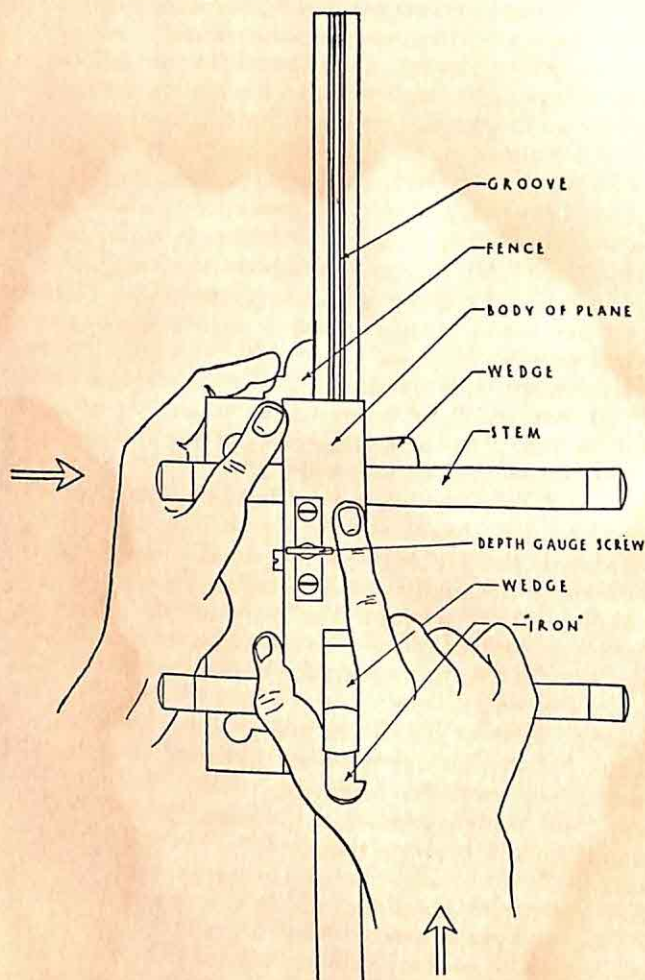


FIG. 56. THE PLOUGH

A plan of the plough is given in Fig. 56. The two main portions are the *body* of the plane and the *fence*; two stems

attached to the fence enable the body of the plane to be moved any desired distance across the wood, and wedges tighten the body on the stems. The following is a point to note when setting the distance across the wood; allow a little extra distance (say $\frac{1}{32}$ in.) at the back. This makes for easier working by preventing binding. The depth gauge is set from the cutting edge of the iron, not the bottom of the skid.

The diagram shows the grip used when working the plane. Adopt the same stance as for other kinds of planing. While the left hand pushes the plane tightly against the face, the right hand drives it along. The groove must be started at the forward end; when this is nearly full depth, draw farther back, cut down and repeat throughout the length. A final shaving or two right along makes a clean finish. During the operation the plane must be held perfectly upright, or the groove will be a bad shape.

When forming wide rebates it is a good plan to make several grooves, chop out some of the waste between them; finish with a jack plane or a badger plane (the latter is a plane having the cutter flush with one side).

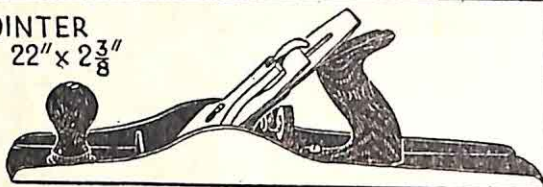
A near relative of the plough is the *sash fillister* (not illustrated); this plane has a cutter 1 in. wide and will make a wide rebate on the far edge of the wood. Plough and sash fillister are both obtainable with screw stems for easy adjustment. Wooden nuts position the body on the stems. Steel combination planes may also be obtained to combine both functions along with other operations like moulding to various sections.

Wooden ploughs and fillisters are set with a hammer, but it must be noted that no part of the body is struck. The cutter and wedge both have suitable places for tapping back. The stems and their wedges are the only other places to be tapped, and then only quite lightly.

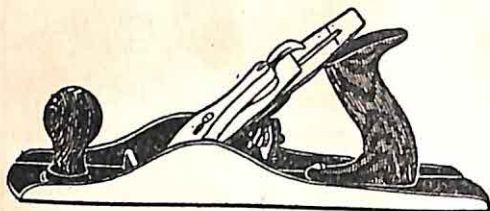
Rebate. Wooden rebate planes are suitable for work along the grain, but steel shoulder planes are more adapted for fine work on end grain, particularly when fitting shoulders to mortise and tenon joints. Bullnose rebate planes are able to work into corners, particularly those planes which have a detachable front.

Block. A most useful little steel plane for small careful fitting. All these special steel planes have single irons set at

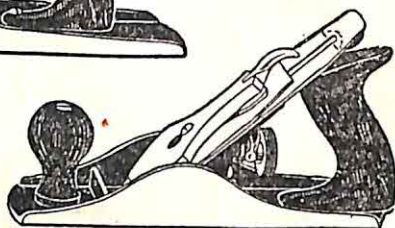
JOINTER
07 22" x 2 $\frac{3}{8}$ "



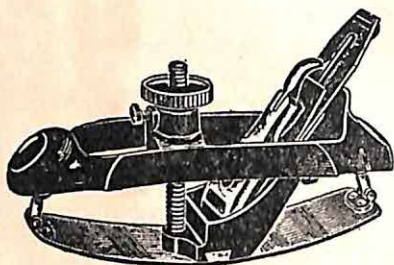
JACK
05 $\frac{1}{2}$ 15" x 2 $\frac{1}{4}$ "



SMOOTHING
04 $\frac{1}{2}$ 10" x 2 $\frac{3}{8}$ "



CIRCULAR
020 10" x 1 $\frac{3}{4}$ "



SHOULDER
072 8 $\frac{1}{8}$ " x 1"

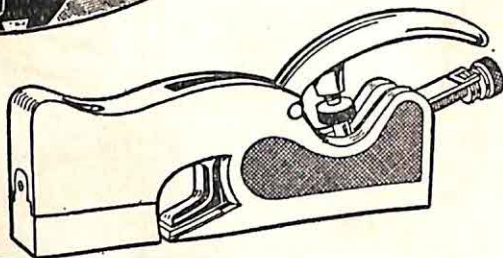
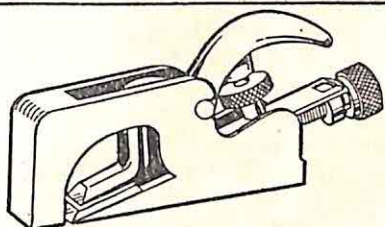
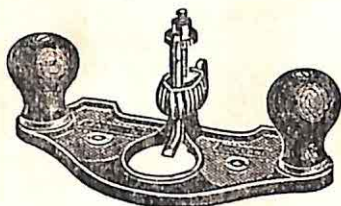


FIG. 57 (a). STEEL PLANES
(By courtesy of Messrs. C. & J. Hampton, Ltd.)

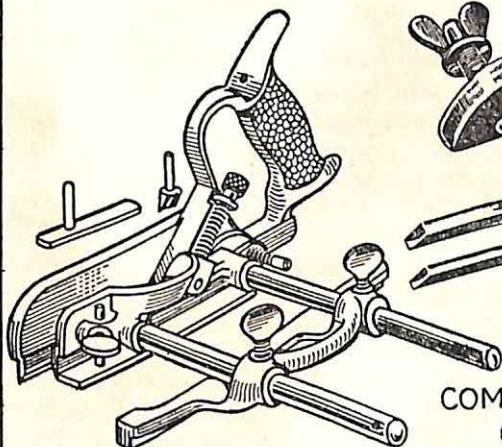


BULLNOSE
077 4" x 1 $\frac{1}{8}$ "

BLOCK
09 $\frac{1}{2}$ 6" x 1 $\frac{5}{8}$ "



ROUTER
071 $\frac{1}{2}$



COMBINATION
050A

FIG. 57 (b). STEEL PLANES
(By courtesy of Messrs. C. & J. Hampton, Ltd.)

about 20° flat side downward. Cutting and clearance angles are actually the same as described elsewhere.

Moulding. Wooden types are obtainable for all the common mouldings (Fig. 55) and special shapes can be ordered. A large number would therefore be required when various sizes are considered. The steel counterpart is a combination plane, the cutters being interchangeable,

Compass. A steel plane having a thin spring steel sole which is adjustable to concave and convex curves.

Thumb. Tiny planes often made by the joiner for curved moulding work, particularly wreathed handrails.

Steel Planes. These planes, illustrated in Figs. 57 (a) and (b) are available for many purposes. They include (i) the jointer, (ii) the smoothing plane, (iii) the shoulder plane, (iv) the bull-nose, (v) the jack plane, (vi) the circular plane, (vii) the router, (ix) the block plane and in Fig. 57 (b) the combination plane with its plough attachments.

From a knowledge of wooden planes for similar purposes their functions should be obvious. All will do specially true work if properly set and sharpened and many of them have mechanical means of adjusting the cutting iron to a fine set.

All must be used individually and to a considerable extent before their value and particular qualities are appreciated.

GRINDSTONES AND OILSTONES

Grindstones are of two main types—the large stone running comparatively slowly in water, and the high-speed grinding wheel running dry. The former is a natural sandstone and the sufficient use of water prevents the steel becoming hot; this danger does, however, exist with the high-speed wheel manufactured from carborundum or emery grit. For choice therefore the wet type is to be preferred for joiners' tools, so that all risk of spoiling the temper of the steel is obviated.

Oilstones. There are many grades of artificial stone, from very coarse cutting to fine. Most of the natural stones used for this purpose range from fine to very fine. Those most commonly used are of carborundum (very coarse to medium), manufactured material which wears down rather quickly. "India" stones are very hard artificial stones, obtainable in several grades; but the medium grade is the one which can be recommended for general use. Washita is a natural stone

which, by reason of its slow fine-cutting qualities, imparts a very keen edge to the finer woodcutting tools.

Oil. It is important that only a good quality lubricating oil is used on oilstones. Its purpose is to keep the pores of the stone quite free from the fine particles of steel removed from the tools in sharpening. Anything which would tend to clog the pores (such as linseed oil) is to be avoided.

When an oilstone becomes worn to a hollow shape, it can be cut down by rubbing on a flat hard stone sprinkled with sand and water, or on a sheet of rough emery cloth laid flat.

SHARPENING PLANES AND SCRAPERS

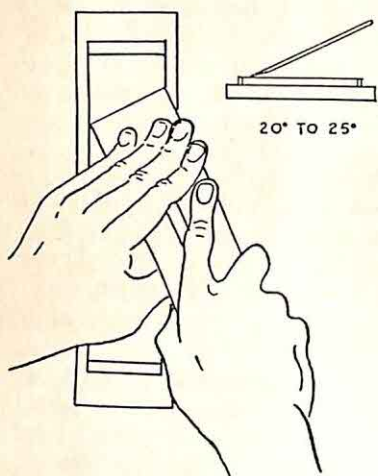
Plane Irons (Fig. 58). The back iron must always be removed before attempting to sharpen the cutting iron. The angle at which the cutter is held while sharpening will depend upon the condition of the grinding bevel. If freshly ground, the cutter may be held at a small angle to the horizontal, but the angle will increase with successive sharpenings. It is essential that a uniform angle be maintained while rubbing along the stone and that the pressure is even, in order that the cutting edge may remain square to the long edges. Directly a slight burr can be felt the iron is turned over, laid perfectly flat and rubbed gently a few times. It is usual for a craftsman to use two grades of stone; a coarse one removes steel quickly but leaves a rough edge, so that a fine one is used for finishing.

If a "wire" edge is left after the sharpening operation, the cutter may be stropped on leather, or on the hand (when the hand has become hardened by work and experienced in wielding the cutter).

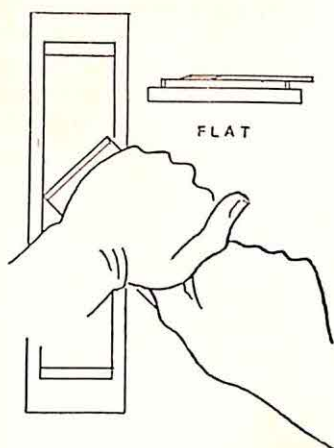
Chisels are sharpened in the same way, but more care will be needed to keep the edge square. There is also a greater tendency to overdo the rubbing, thus shortening the chisel and bringing nearer the time when another must be bought.

For the sharpening of gouges, shaped stones called oilstone slips are used.

Scraper. (Fig. 58). This is a thin steel blade with a straight burred edge, used to finish hardwood after the smoothing plane and before glasspapering. Properly set up, a scraper will remove shavings very much like a finely-set plane. It is, however, quite difficult to bring the scraper to this state of efficiency. The edge is first filed straight and square, with a



SHARPENING



REMOVING BURR

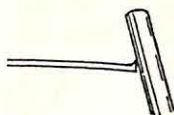
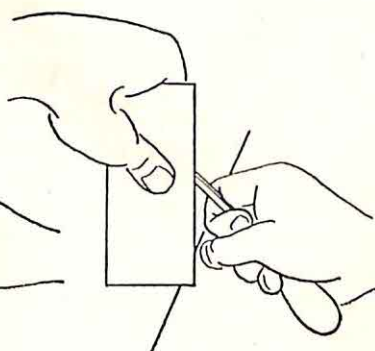
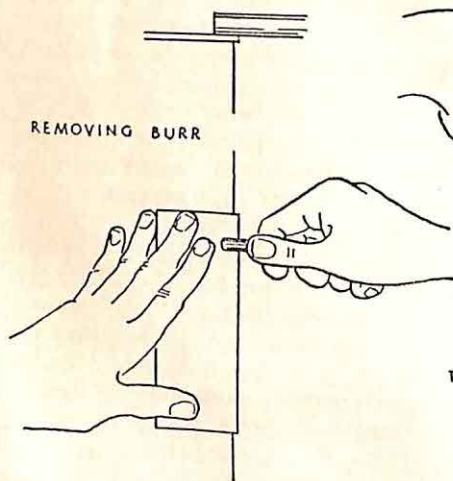


FIG. 58. SHARPENING OF PLANE IRONS AND SCRAPERS

flat file, and finished on an oilstone. A burnisher of hardened steel is then used to remove any burrs on the flat side before setting the scraper on end and turning the edge over. Successive burnishings will cause the edge to become rounded; in which case filing and stoning must again be done.

ABRASIVES

Glasspaper is made in many grades, from OO to S2, by glueing powdered glass to stiff paper. The joiner uses glasspaper to impart a finish to the surface in preparation for polishing or painting. Its purpose is to remove plane and scraper marks; and it would be a very laborious method of removing anything but a very minute amount. In order to avoid uneven abrasion the paper is wrapped round a "rubber" or a piece of cork, or failing that a piece of wood surfaced with cork lino. For mouldings a piece of soft wood is shaped for the purpose.

Painters use a special kind of water-resisting glasspaper for use in conjunction with water in rubbing down paintwork.

Emery Cloth. This is also obtainable in many grades. It is made of emery powder attached to linen; the best of the kind being "blue-back." The carpenter and joiner use a fine grade, with lubricating oil, for keeping steel tools bright.

TEMPLETS

For cutting operations which have to be repeated to one condition or one pattern it is useful to employ a templet specially designed for the purpose. Square templets and mitre templets are to be found in most joiners' kits because of the frequent uses for them.

Mitre and Square Templets (Fig. 59). The mitre templet is used not only for guiding the chisel when making mitres to mouldings worked on the solid, but also for the first operation in starting to scribe a moulding. The small sketch shows an additional use to which it may be put. An extra slip may be screwed to the edge and removed when not in use; with the slip it becomes suitable for internal mitring, as with bead flush panels.

The square templet has many uses, particularly when marking square lines across mouldings and chamfers. The extra depth of stock makes it adaptable to positions where a try-square could not be held against a face or edge.

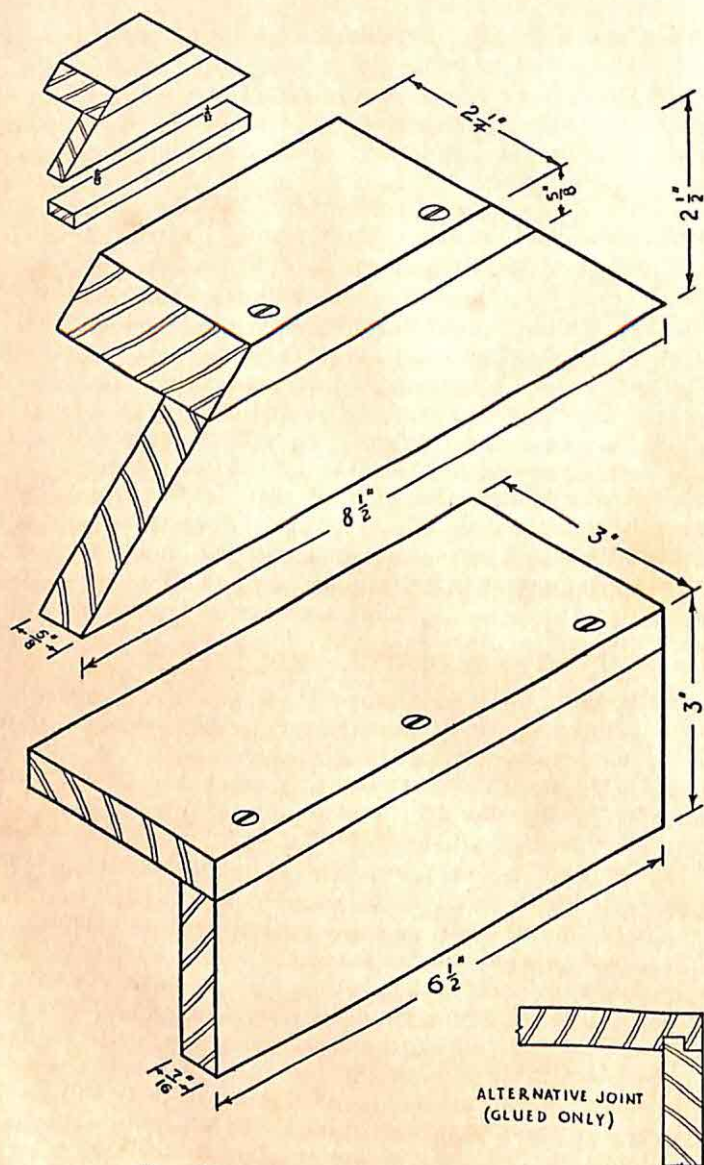


FIG. 59. SQUARE AND MITRE TEMPLITS

It is a useful exercise, involving accurate work, to make these templets. Select a clean straight-grained piece of hardwood. Beech or walnut is most suitable, but oak or mahogany are quite good alternatives. The material must be planed true. A choice of joints is shown; of the two, the glued and screwed kind is recommended. This should be glued first and cramped, making certain that the two pieces are perpendicular to one another. When hard, bore suitable holes for the screws. Employ iron screws first to ensure the fit. Replace them by brass screws; leave the heads standing up very slightly, to be filed and glasspapered flush with the surface subsequently.

The tongued and grooved joint does away with the need for metal fixings, but to obtain a good fit and ensure squareness is quite difficult. Another way of obviating metal is to cut the templets from a solid block. Neither of these methods is likely to be as strong as the glued and screwed joint.

The cutting and planing of the ends should be left until the long sides and edges have been checked for truth. The outside faces may be glasspapered carefully and the finished articles given a coat of french polish to prevent dirt becoming ingrained when they are in use.

OTHER USEFUL IMPLEMENTS

Bench Scraper. A most useful implement, this is best made with a plane iron which has outlived its true vocation. This type is used for scraping glue, paint and dirt from rough timber or the bench top. Other tools are thus given a better chance of being effective, for glue, etc., play havoc with sharp plane and chisel edges.

Let a bench scraper (Fig. 60) be made as a workshop exercise. Having acquired the nearly-spent plane iron, have two countersinkings put near the ends of the slot to house the heads of No. 14 screws. A metal working shop is the best place for this operation, as woodworking countersink bits are not usually of sufficiently hard temper to withstand use on steel.

When a suitable piece of hardwood has been planed up the shoulder is marked and a parallel line about $\frac{1}{4}$ in. away marked for the waste, which can be sawn off straight away. Place the iron in position on the end and mark inside the slot with a sharp pencil. Saw the shoulder as far as possible and chisel away the rest. Fit the iron on tightly, and bore suitable screw holes.

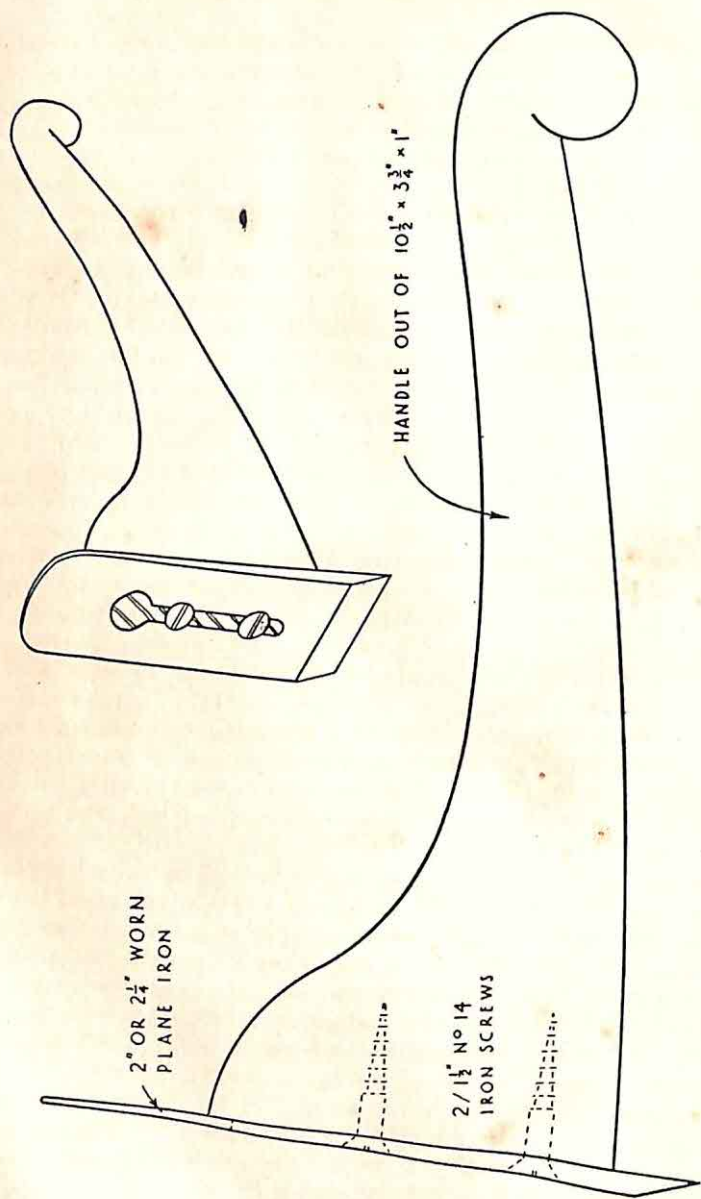


FIG. 60. BENCH SCRAPER

The shaped handle may be bow-sawn and a half-round edge worked all round with the spokeshave. Proceed by working a $\frac{1}{4}$ in. $\times$ $\frac{1}{4}$ in. chamfer all round first, then removing the two edges so formed, and so on.

Various alternative fixings for the cutter are available: a tusk tenon may be brought through the slot, with one or two wedges passing through it to force the cutter on to the shoulder; two short coach bolts with handrail nuts might be let into the stock; or washers and round head screws might be employed. The fixing shown is the tidiest of them all and is very efficient.

In use, the scraper is pulled towards the body with the handle in the horizontal position. It is advisable to keep the outline of the cutting edge well curved to avoid the corners digging in and damaging work or bench top.

Router or Old Woman's Tooth (Fig. 61). The latter is the more common name among craftsman, the more dignified term being reserved for the more expensive steel router—a nicer tool, having screw adjustment for depth of cut (Fig. 56 (b)). The homely wooden kind has its advantages however, being better adapted for heavy cuts. Heavy cutting is achieved by tipping the tool on its front edge and, as the waste is removed, gradually lowering the back until the final depth is reached. The older form may be made by a really good student, but is a difficult enterprise.

It is well to obtain the cutting irons (in various widths) before beginning the plane, as the thickness of these will govern the size of the mortise. Quite often one may acquire second-hand plough irons, but failing this, $\frac{3}{8}$ in., $\frac{1}{4}$ in. and $\frac{1}{8}$ in. cutters should be purchased.

For the body of the plane, select a piece of hardwood such as beech, birch, or walnut. Oak and ash are not generally suitable on account of a tendency to split under the action of the wedge. Incidentally, the body of the plane is often made with the grain running from front to back to overcome the risk of splitting. If reasonable care is exercised when using the hammer, however, this is not a serious matter. The writer has one of the type shown still giving good service after nearly twenty years of hard use.

Plane the block true all round, including the ends, and mark the section on both ends. Set out the mortise and the position of the escapement hole. Remove most of the mortise by boring

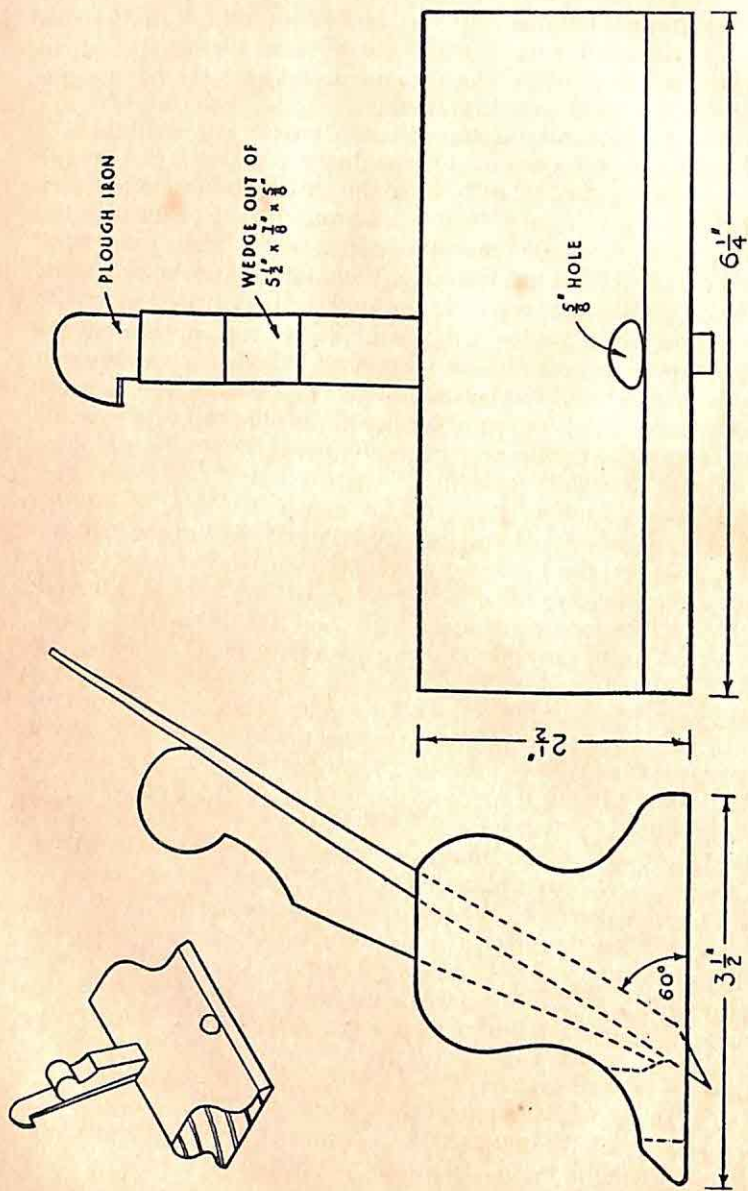


FIG. 61. ROUTER (OLD WOMAN'S TOOTH)

out with twist bits, using $\frac{1}{2}$ in. bit half-way through from the top and $\frac{3}{8}$ in. bit from the bottom. Finish carefully with bevel-edged chisels. The escapement hole is next bored from the bottom, about 1 in. in depth.

The large piece of waste at the front may be removed by making two saw cuts, using it later for making the wedge. Use a rebate plane to remove as much of the section as convenient, and finish with hollow and round planes. The outline of the wedge is then marked, the taper planed, and the shaped portion worked by paring vertically with chisels and gouges. Fit exactly to mortise with the cutter in position, and with glasspaper wrapped on a piece of dowel rod streamline the bottom end around the escapement to facilitate the passage of shavings. Finally, glasspaper well and either french polish (except the sole) or apply linseed oil liberally at weekly intervals.

SECTION III

MATERIALS

THE materials used by the carpenter and joiner include many kinds of sawn timber, both home and foreign grown; and several varieties of prepared wood in the form of plywood, blockboard, laminboard, and fibreboard. Plywood with special veneers is in common use.

For processing and fixing, glasspaper, glue, nails and screws are required.

For plane grinding and sharpening, grindstones, grinding wheels (carborundum, etc), and oilstones are necessary.

These materials are considered in the following pages.

TIMBER

Trees and Wood. It has been said that if wood were to be suddenly discovered for the first time, it would be acclaimed as the most nearly perfect of materials. Its weight-to-strength ratio, adaptability, workability and low cost are qualities which make it eminently suited to scientific design. The Mosquito aeroplane is probably the best modern example of a product making use of all these advantages.

As to the additional pleasing properties possessed by wood, a concert piano and a violin would seem to be the examples which embody them most aptly. Wood has satisfied so many of man's needs for so long that it has come to be taken for granted; so much so that the virtue of new materials is often judged by their ability to imitate some of its properties.

The prime needs of mankind are usually taken to be food, shelter, and clothing. How far are these needs satisfied by the products of trees? Certainly vast quantities of food are provided as in the form of fruits, oils, fats and cereals of the sago and tapioca type. Shelter is provided for a large proportion of mankind by timber and other products of trees, particularly in Russia and the Scandinavian countries, Canada, America and Japan. The primitive dwellings of native peoples in tropical countries are often made of trees bound with fibre and thatched with leaves. Clothing is a field in which timber

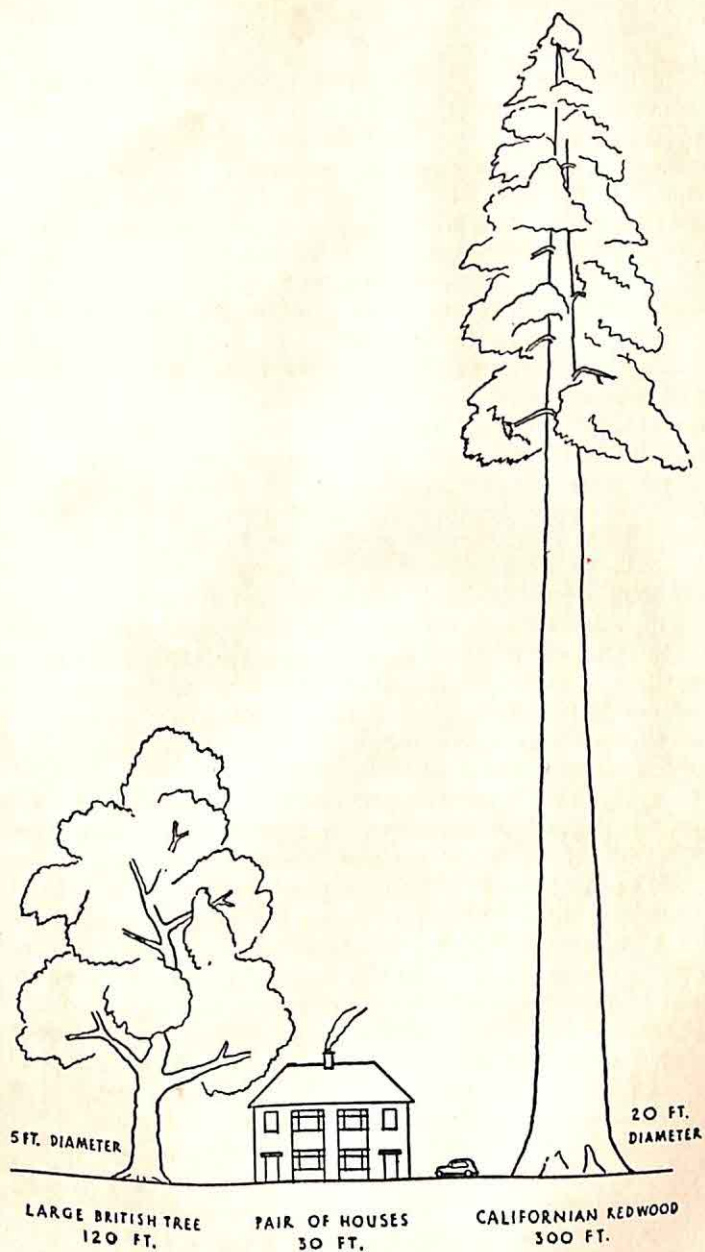


FIG. 62. TREES: COMPARATIVE HEIGHTS

products are gaining in importance, artificial silk and the German *ersatz* cloths being notable examples.

Civilization, however, demands something more than the bare necessities; for instance, transport of all kinds. Very little thought will show the importance of timber here (carts, lorries, railway coaches, track sleepers, barges, ships and aeroplanes). Among other products of trees, rubber has wide significance; the raw material for paper comes from trees; and still further examples of man's dependence upon trees can be found in furniture, tools and implements of all kinds.

What more friendly and beautiful material could be imagined than wood, for fashioning the multitude of things great and small that man needs for his existence and comfort?

Small wonder, then, that the future supply of timber is treated as a matter of extreme importance by far-sighted governments; for, while it is true that one-fifth of the earth's surface is covered by trees, much of this potential timber is not easily accessible. It exists far away from transport of the type most suitable (i.e. sea and river); while other kinds of transport are often prohibitively expensive. It is probable that counting reasonably accessible timber only, the demand is overtaking the supply. Britain alone normally imports 412 million cu. ft annually; this would cover an area of one square mile to a depth of 15 ft.

Climate. This has an important influence on the growth of trees; conversely trees have an influence on local climatic conditions. To take the latter point first, an important function of trees is to bind the top soil and retain it in the face of the elements. Another is to conserve moisture and warmth. Cold winds are diverted and warmed by large expanses of trees; and intense heat of the intermittent kind is reflected by the leaves, thus making wooded places cool in hot weather.

Great tracts of land in America have become desert because trees were cut down and corn crops grown instead. In this way the soil, deprived of roots to bind it, dead leaves to replace plant food, and the bulk of the great trees to divert or at least break the force of the wind, became dry and loose and was blown away. Much the same thing happened in China and in what is now the Sahara desert.

Climatic conditions have a decisive influence on tree growth.

It is only in the Polar regions and in the arid desert that trees cannot exist at all; the kinds of tree which grow in other places are determined by prevailing weather conditions during the growing season.

Near the Equator the growth of trees is continuous and they are evergreen; as we travel towards the Poles, deciduous trees occur in the temperate zones and needle-leaf evergreens in the colder regions. A great belt of softwood timber trees extends across Northern Europe, Canada and America, Britain lying slightly South of the zone. British trees are largely deciduous trees yielding hardwood (oak, ash, beech, elm) and these timbers are found in corresponding latitudes on the continents of Europe and America. Similar zones occur in the Southern hemisphere, but on the smaller land masses of Australia, New Zealand and South America.

Whilst latitude is the chief factor in determining types of trees, altitude also has an influence; and conifers are found on mountains in quite hot climates.

Trees. Trees may be divided into three groups—acrogens, endogens, and exogens.

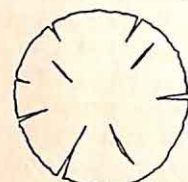
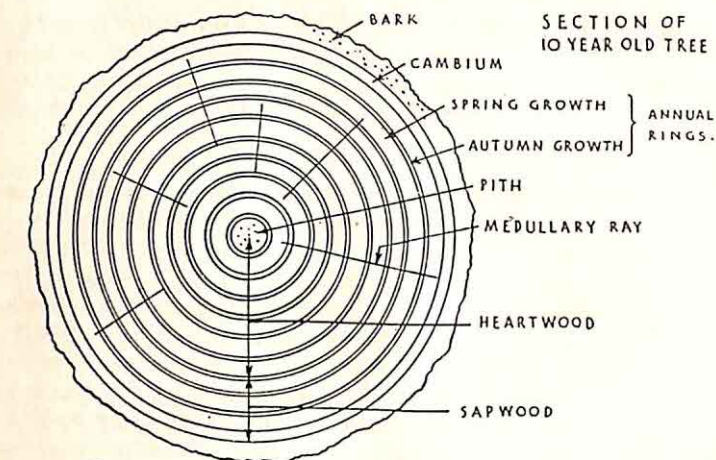
Acrogens, or summit-growers, include the banana and bamboo, yielding chiefly fruit and grain, but also thatch and wood of a sort.

Endogens, the inward-growers or palms, yield fruit, grain (sago), oil, wine, resin, thatch, timber, fibre for rope, etc., and a multitude of other things.

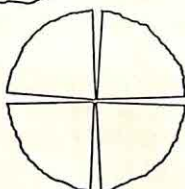
Exogens, the outward-growers, yield fruit, rubber, cellulose, oils, and spirits among other things; and, of course, timber as we know it.

Exogenous trees grow by putting on successive layers of growth immediately under the bark. In the tropics this is a continuous process but in temperate and cold climates there are two distinct periods for the addition of fresh layers. In spring when plant food travels from roots to branches, a layer of soft quick growth is put on. During summer the leaves manufacture a rich sap which descends the tree in the "fall" leaving the foliage dry, but putting on a harder layer of growth and feeding the inner parts of the tree by way of the medullary rays (see Fig. 63).

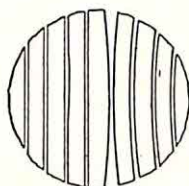
The annual rings vary considerably in thickness; $\frac{1}{8}$ in. to $\frac{3}{8}$ in. is quite usual. As the tree matures, the centre portion



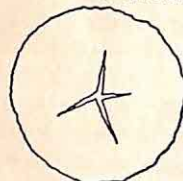
STAR SHAKE (RESULT
OF DELAYED CONVERSION)



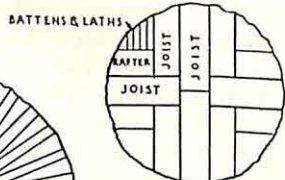
QUARTER-SAWN LOG
(SHRINKAGE IS GREATEST AROUND ANNUAL RINGS)



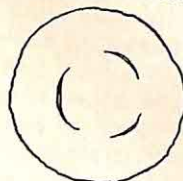
SAWN THROUGH & THROUGH
(SHRINKAGE IS GREATEST AROUND ANNUAL RINGS)



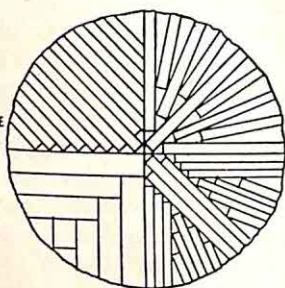
HEARTSHAKE - DUE TO AGE



VARIOUS BUILDING TIMBERS



CUPSHAKE



VARIOUS WAYS OF CONVERTING
A QUARTERED LOG



FIG. 63. SECTION OF TIMBER TREE. DEFECTS AND CONVERSIONS

becomes stronger by thickening of the cell walls of which the wood is composed. This gives the tree its "backbone" and is known as heartwood. The wet sappy wood which normally occupies roughly the outer third of the trunk is the crude wood which, as successive layers are put on, becomes heartwood in turn.

Various species of trees may reach maturity in anything from 50 to 1000 years (ash and Californian redwood respectively). Tropical woods often reach a height of 300 ft and a diameter of 20 ft. The best timber trees grow in forests where, in its struggle for sunlight and air, the young tree grows straight up without branches. In open parks, trees grow more decoratively but branches are thrown out too quickly, and this fact combined with the pressure of wind causes gnarling and twisting of the stem. For this reason British grown trees may yield a butt 15-20 ft, whereas similar trees from Russian forests give 40-60 ft, and tropical trees up to 120 ft. Fig. 62 shows comparative sizes of trees.

In countries where afforestation is given the importance which it deserves, young trees are planted close together to make them grow tall and straight, and thinned out later to give room for growth.

FELLING. While a tree may continue to live long after reaching its prime and still put on fresh growth, the heartwood begins to deteriorate and the timber loses its value. The forester knows when a tree has reached its full vigour by observing the crop of leaves at the top.

Up-to-date lumbering is highly mechanized, but in this country hand-felling is still practised. Once the tree has been felled it should be converted to usable sizes as quickly as possible. In this way unequal drying-out is avoided.

At a later stage, seasoning of the timber entails evaporation of the moisture. In green timber moisture may be over half the weight of the log. In heavy timbers like teak, this is a major problem, for the added weight causes the timber to sink in water. Teak trees are therefore "ringed" some years before felling. That is, the cambium layer is cut through to stop the sap rising; the tree then gives its moisture to nourish the leaves until such time as it dies, when it is felled and can be floated down-river.

Other heavy timbers which do not lend themselves to this

treatment may be attached to lighter logs, and light and heavy logs go floating down together. With ordinary timbers it is sufficient to arrange for felling during winter or summer when the minimum amount of sap is in the trunk.

CONVERSION (see Fig. 63). A table mounted on rails carries the log back and forth, while a band saw converts it to planks or boards of the sizes required. The use to which the timber is to be put will determine just how this conversion is to be done. The easiest way is to leave the log in one position and saw slabs off, but this does not necessarily produce the best timber. For certain uses a better, though expensive way, is to saw the log into four parts and then, as far as possible, radially along the line of the medullary rays. This method entails a larger amount of waste, but the timber is more satisfactory in use; and many hardwoods (particularly oak) gain in appearance by reason of the medullary rays showing on the surface. This is variously described as the "figure" or "silver grain" (see Fig. 64).

In timbers having medullary rays not sufficiently well defined to give silver grain, the first method of sawing produces decorative flowered effects; much to be desired for subsequent conversion into veneers.

Veneers. Precious and decorative woods are converted into thin leaves or veneers usually $\frac{1}{32}$ in. thick; these leaves are later glued to less decorative or less expensive woods. To obtain veneers, the board is soaked thoroughly before being put into a machine which cuts slices off with a knife.

Veneers are used in the making of plywood. In this case a log is soaked thoroughly and then placed in a machine which turns it against a knife, so peeling off a veneer around the circumference of the log.

SEASONING. This means, approximately, drying. It is not as easy as that, however. Freshly felled timber contains a great deal of water, often over half the total weight. If a piece of wood is left in the open air, most of this water gradually evaporates; if it were put in an oven the moisture would be driven off very rapidly. Another aid to ridding some timbers of unwanted moisture, strangely enough, is to place them in running water. Sticky materials are dissolved and removed which would otherwise clog the wood and stop moisture getting away.

These aids to evaporation are sometimes described as the three methods of seasoning—air seasoning, water seasoning, and kiln (oven) seasoning. It is, however, quite usual to employ two or even all three of these aids, and the water treatment is only a preliminary to air or kiln drying.

By putting a sample of wood in an oven maintained at a temperature of 100° C (212° F) all the free moisture can be driven off; the dry state is determined by weighing at intervals and ceasing the heat treatment when successive weighings show no change. This last weight is the weight of the actual wood. If the same sample is left in a humid atmosphere, it will gain weight and successive weighing would show a stage where this gain ceases. Absorption of moisture takes place until the sample is in equilibrium with the atmosphere.

The difference between the weight of the actual wood and its weight when moist will give the weight of water which has been absorbed; or

Wet weight — Dry weight = Weight of water
and

$$\begin{aligned} & \text{Percentage moisture content (M.C.)} \\ &= \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100 \end{aligned}$$

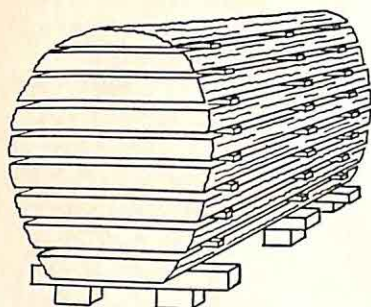
This is the formula by which the condition reached in the seasoning of timber is estimated. By experiment and calculation the final condition can therefore be controlled.

Research has found what moisture content in timber is desirable or to be expected in a given situation; the aim of seasoning is to dry the timber to that stage before use. According to the situation and use of the timber, the moisture content may vary from 8 to 25 per cent.

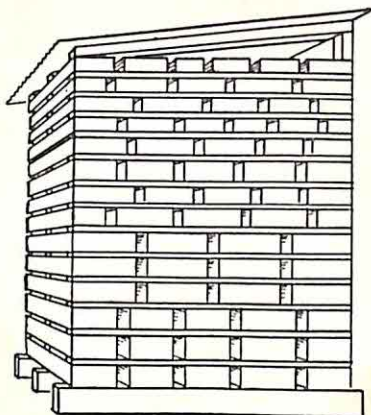
Water seasoning. The logs are anchored by chains below the surface of running water or simply left in still water for a week or two. Much timber receives this treatment by being floated down rivers in the early stages of its transportation.

Air seasoning (Fig. 64). The wood is converted and carefully stacked to keep it flat, in such a way that a free circulation of air can make its way around the timbers. The stack may be made under a skeleton building supporting a roof, or may itself be roofed over. The length of time needed to evaporate

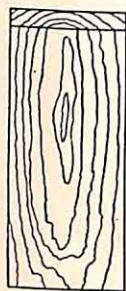
AIR SEASONING



HARDWOOD LOG SAWN
'THROUGH & THROUGH' & 'STICKED'



STACK OF DEALS (SOFTWOOD)
ROOFED OVER



TANGENTIAL SAWN
(PITCH PINE)



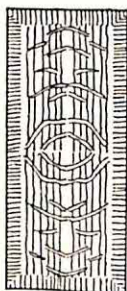
RADIAL SAWN
(SOFTWOOD)



RADIAL SAWN
(OAK)

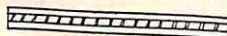


MATCHED
VENEERS



QUARTERED PANEL
CROSSBANDED MARGIN

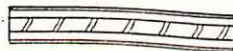
TYPES OF LAMINBOARD



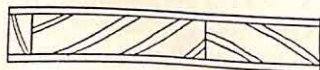
THREE - PLY



MULTI-PLY 5, 7, 9, ETC.



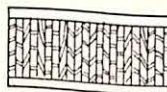
METAL FACED PLY



SLAB CORE



BLOCK CORE
WITH DOUBLE OUTER SKINS



LAMINATED CORE

FIG. 64. AIR SEASONING. FIGURED AND MATCHED
BOARDS. PLYWOOD, BLOCKBOARD AND LAMINBOARD

the moisture varies with the thickness and the species. Anything from one to five years may be necessary.

Kiln Drying. This is the method in general use nowadays because it is rapid. The process needs very careful control and must not be unduly hurried. Briefly, the timber is stacked open fashion on rail trolleys and is pushed into a chamber where moist heat and dry heat, i.e. steam and hot air can be supplied and controlled. This stream of conditioned air moves through the pile of timber, drawing out the moisture at a carefully controlled rate and carrying it away to the outer air. Samples are taken out of the pile at intervals and tested for moisture content, and the moisture content of the air draught adjusted accordingly. A hygrometer is used to determine the moisture content of the air.

A simple form of hygrometer (Fig. 65) consists of a pair of thermometers one of which has the bulb kept wet by a wick dipping into water. The evaporation of liquid around the bulb causes cooling, and the degree of evaporation depends upon the moisture already present in the air. Thus the difference in reading between wet and dry bulb thermometers depends upon the dryness of the air and can be used as an indication of the amount of moisture in the air by reference to tables.

If timber has already been partly dried by air seasoning, one to five days may be sufficient time for the kilning process. If not the process may take one to three weeks.

Defects in Timber (see Fig. 63). *Shakes* are caused by uneven drying of the wood. For instance, the ends of converted timber always dry out more rapidly than other parts, with consequent splitting. Shrinkage due to loss of moisture is greatest around the annual rings (about twice as much as radially), causing star shakes in the log and warping in boards. Cup shake and heart shake occur where the heartwood shrinks, due to the beginning of decay in the tree.

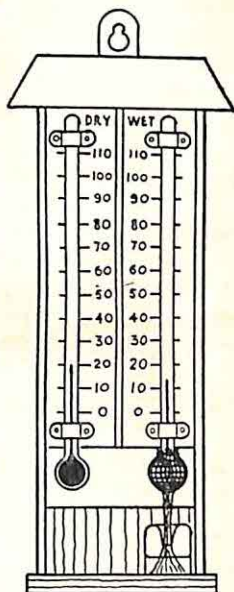


FIG. 65.
HYGROMETER

Knots. The young sapling throws out branches quite near the ground, which are subsequently grown over and round by successive layers of tree growth. If the branches continue to grow, live knots are the result. If the branches die, and the timber grows around them, dead knots are formed. Contrary to popular belief, branches do not move upwards with the growth of the tree, but remain at the same distance from the ground.

Discoloration may be caused by decay in heartwood, variously described as foxiness, doatiness, and druxiness; or to immaturity, as in the blue markings in the sapwood of fir.

Upset describes a sudden break in the continuity of the grain if the timber has been damaged in felling, or subsequently while floating down river; the break is a source of weakness.

Sleepiness and Case-hardening are both the result of poor kiln drying. The first is a condition of lifelessness in the wood, which is brittle and dull. Case-hardening is caused by too quick drying, the outer skin being hard; when the wood is cut, warping takes place because moisture continues to evaporate from the inner parts.

Waney edge is the edge of a board which shows a part of the rounded outside surface of the tree; it has not been cut off during conversion because the machinist has been too anxious to get the most out of the log.

Diseases. By far the most notorious is *Dry Rot*. Fungus attacks timber containing more than 20 per cent moisture content, particularly in unventilated situations. It must be guarded against from the moment of felling by not allowing the timber to lie about on vegetable earth, or be built into unventilated situations.

Wet Rot is the decomposition of timber under the action of frequent soaking and drying. Timber in fence posts below ground is very liable to this disease.

Insect Borers. Wood worms and beetles eat the wood away. Furniture and roof timbers are most liable to suffer.

Preservation. Where experience shows that timber will be subjected to the attacks of disease, prevention is much better than subsequent attempts at cure. Railway companies, and other business undertakings who do their own building, know that the initial expense is saved many times over.

CREOSOTE is a great preservative. Railway sleepers, and

telegraph poles, among other things, are impregnated with creosote. This is done by putting in a tank under pressure or by steeping in the hot liquid. Good builders steep fence and gate posts in large barrels over a fire. Brushing the liquid on is effective only when applied well above ground level and renewed annually.

OIL, PAINT AND VARNISH. *Linseed Oil*, under suitable conditions, forms an elastic skin on wood. Several applications are needed because the wood absorbs the oil at first. Boiled oil dries and hardens more quickly but is not quite so good.

Oil Paint is a mixture of oils, an opaque body or base, a colouring pigment (if required) and a thinner for ease of working. The latter must be a liquid which readily evaporates, turpentine and white spirit being commonly used. Several thin coats are better than one thick one. Usually the priming coat is used to seal the grain; followed by flat colour (with little oil) to give a non-glossy foundation for the final coat, each coat being rubbed smooth with glasspaper before the next is applied. Four coats are considered a minimum on good new work.

Varnish is made of gums and resins and may be applied directly to the wood or in combination with a final coat of paint. Different qualities are available for interior and exterior use.

Any skin treatments must be renewed when signs of fatigue occur, either by cracking, peeling, or exposure of the wood.

STAIN, WAX AND POLISH. Woods having a pleasing appearance in colour and grain are given a transparent finish. If the natural colouring is not exactly what is desired, the wood is stained first.

Water Stains are of two kinds, those which have a chemical action, and those which deposit particles of pigment on the wood.

Potassium Bichromate, dissolved in water in varying strengths, imparts a richer tone to mahogany (chemical action).

Liquid Ammonia fumes give oak a weathered appearance (chemical action).

Vandyke Brown, *Brown Umber*, *Red* and *Yellow Ochre* are pigments which may be mixed in varying proportions in water and used to stain softwoods to imitate more expensive hardwoods, e.g. oak, walnut, mahogany.

Any water stain causes the grain of wood to swell unevenly, making subsequent rubbing down necessary. Spirit stains do not have this effect and are therefore preferable.

Spirit Stains and *Oil Stains* are sold only by a few retailers of polishers' materials. They are made up in a few shades only, and mixed to customers requirements. Proprietary stains in labelled bottles have a creosote base and are inferior imitations which retard the setting of varnish indefinitely, but fortunately have no harmful effects on french polish.

Varnish Stain cannot be regarded as a satisfactory finish for good work. A streaky finish is almost inevitable.

Beeswax is bought by weight in lump form and can be rubbed directly on the wood, or shredded and dissolved overnight in turpentine and applied like furniture polish. The first method needs considerable "elbow grease" with a rag and is seldom satisfactory; the second means that the wax is easily applied and finished, but the wood easily picks up dirt thereafter. There are several inferior imitations of beeswax, easily detected by lack of the characteristic smell.

French Polish is the finish employed on the finest of joiners' work. The polish is made of shellac and gum dissolved in methylated spirits; but it is advisable to buy it ready made from a good supplier. It is applied with a pad of cotton wool wrapped in rag. As polishing is a skilled craft, some practice will be needed to achieve even the moderate results usual on oak and commonly described as "wax finish."

Density. The density of timber is usually given in lb/cu. ft. Given a sample of timber, its density can be determined by finding its volume and weight; then

$$\text{Density} = \frac{\text{Weight in lb}}{\text{Volume in cu. ft}}$$

EXAMPLE. A sample of yellow deal 18 in. $\times$ 4 in. $\times$ 3 in. weighs 4 lb.

$$\text{Volume in cu. ft} = \frac{18 \times 4 \times 3}{12 \times 12 \times 12} = \frac{1}{8} \text{ cu. ft.}$$

$$\therefore \text{Density} = \frac{4}{\frac{1}{8}} = 4 \times 8 = 32 \text{ lb/cu. ft.},$$

or if $\frac{1}{8}$ cu. ft weighs 4 lb, 1 cu. ft will weigh 32 lb.

Another method is to determine its weight relative to that

of water (Relative Density or Specific Gravity). A stick of wood 10 in. long, of regular cross section (say 1 in. square) is prepared and put endwise into water (see Fig. 66). If it submerges half-way its relative density is 0.5. Since water weighs $62\frac{1}{2}$ lb/cu. ft its weight per cubic foot must be $31\frac{1}{4}$ lb.

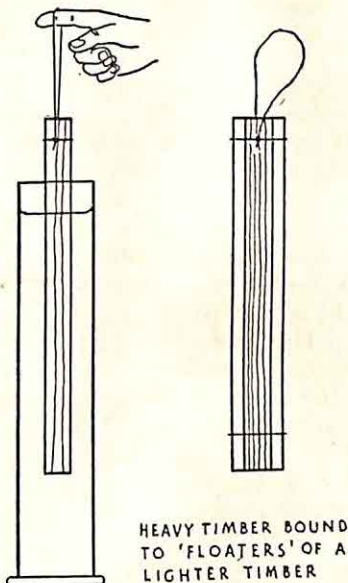


FIG. 66. DENSITY OF TIMBER BY FLOTATION

To justify this assertion, Archimedes' principle may be stated in the following form—

When a body is wholly or partially immersed in a liquid, the liquid exerts an upward pressure on the body equal to the weight of liquid displaced by the body. It follows that if the body is supported by the upward thrust of the liquid, (i.e. if it floats) the weight of the body is equal to the weight of the liquid displaced.

$$\text{Hence—} \frac{\text{Submerged volume}}{\text{Total volume}} = \frac{\text{Density of body}}{\text{Density of liquid}}$$

$$\therefore \frac{\text{Submerged volume} \times \text{Density of liquid}}{\text{Total volume}} = \text{Density of body.}$$

Note that the volume of a solid of regular cross section is proportional to its length.

EXAMPLE. A certain sample was wetted a distance of 8.75 in. along its length of 10 in.

$$\text{Density} = \frac{8.75}{10} \times 62\frac{1}{2} = 54.75 \text{ lb/cu. ft.}$$

WOODS HEAVIER THAN WATER. A wood which has a greater density than water will sink, so a modification of method is necessary.

Prepare two "floaters" of a lighter wood, each half the usual width but the same thickness. Bind them with cotton and determine the density of the lighter wood. Now bind the floaters one on either side of the heavy sample and determine the combined densities.

Suppose the results are: light sample = 30 lb/cu. ft; combined sample = 50 lb/cu. ft.

Let density of the heavy sample = x , and density of the light sample = 30.

Average density of the two samples = 50.

$$\text{Then } \frac{x + 30}{2} = 50$$

$$x + 30 = 100$$

$$x = 100 - 30 = 70 = \text{density of the heavy wood.}$$

Three points must be borne in mind in connection with these experiments—

(1) Samples of the same species of timber will vary, and authentic values are averages of a number of experiments.

(2) The experiment must be done quickly, or absorbed water will influence the result.

(3) The sample must not be allowed to sink too far and subsequently "bob" up.

Timber Quantities and Pricing. The more expensive (hardwood) timbers are priced by the cubic foot or by the "foot super as inch." Thus a hardwood might be priced at 12s per cu. ft or at 1s per ft super for 1 in. thick. The latter method is more convenient for pricing boards. For instance a board of mahogany 10 ft $\times$ 9 in. $\times$ 1½ in. at 10d per sq. ft measured as 1 in. = 7½ sq. ft at 1½ in. thick, or 7½ $\times$ 1½ = 11¼ sq. ft

TIMBERS

Wood	Source	Density lb/cu. ft	Uses
Alder	Britain, Europe	33	Plywood, clogs
Ash	Britain, Europe	44	Tool handles, sports goods, waggon building
Balsa	Central America	3 to 24	Non-structural parts of aircraft, model aircraft, film "props," sound and thermal insulation, buoyant parts of life-saving apparatus
Beech	Britain, Europe	46	Tools, kitchen goods, furniture
Birch	Europe, America, Canada	40	Plywood, bentwood furniture, turnery
Canary	U.S.A.	28	Furniture, handicraft, turnery
Whitewood			
Cedar	Canada, U.S.A.	24	Exterior weatherboarding and shingles, joinery
(Western Red)			
Deal	Europe, Britain	33	All kinds of carpenters' and joiners' work
(Yellow or Red)			
Deal (White)	Europe	27	Interior joinery
Greenheart	British Guiana	66	Piles, lock gates, fishing rods
Gurjun	India, E. Indies	46	Sills and heavy constructional work
Jarrah	Australia	56	Flooring and heavy constructional work
Larch	Britain, Europe	37	Fencing, gates, floor joists
Mahogany	America, Africa, West Indies	34 to 48	High-class joinery, boatbuilding
Maple	Canada, U.S.A.	47	Flooring, turnery, veneers
Oak	Britain, Europe, U.S.A., Japan	48	Innumerable
Pine (Yellow)	Canada, U.S.A.	26	Pattern making, superior interior joinery, matches
Pine (Oregon)	Canada, U.S.A.	33	All kinds carpentry and joinery, plywood, flagpoles, railway sleepers, heavy constructional work
Douglas Fir			
Pine (Pitch)	U.S.A.	41	Heavy constructional work
Rosewood	Brazil	53	Tool handles, furniture, pianos, veneers
Spruce	Canada, U.S.A.	28	Pulp for paper, food packing cases, aeroplane construction, oars
Teak	India, Burma	42	Exterior and interior joinery for hard-wear, heavy constructional work, boatbuilding, railway rolling stock
Walnut	Europe, America, Africa, Australia	38	Gunstocks, furniture, veneer, interior joinery
Willow	Britain, U.S.A.	28	Cricket bats, artificial limbs

measured as 1 in. thick. The cost of $11\frac{1}{4}$ ft super at 10d = 9s 4½d.

Softwoods are used in greater quantities, and a larger unit than the cubic foot is found more suitable. The Leningrad (Petrograd or St. Petersburg) Standard is the softwood unit and contains 165 cu. ft.

To find the number of running feet of a given section in a standard, divide the end area into 165 cu. ft.

EXAMPLE. (a) How many running feet of 9 in. × 4 in. are there in a standard?

(b) What will be the cost of 20 ft of 9 in. × 4 in. at £44 per standard?

(a) The sectional area is 36 sq. in., or $\frac{36}{144}$ sq. ft. Therefore $165 \div \frac{36}{144}$ or $165 \times \frac{144}{36} = 660$ ft run.

(b) Cost of 20 ft = $\frac{20}{660} \times 44 = \frac{44}{33} = 1\frac{1}{3} = £1$ 6s 8d.

This example shows how the price is easily worked out; once the number of running feet of a given section has been determined, the figure can be used in future calculations. Tables are available which give the running feet in the usual "scantlings" (stock sizes) and other sections are easily worked from them, e.g.—

9 in. × 2 in. will contain 1 320 running feet per standard, viz.: (2 × 660); 9 in. × 1 in., 2640 ft (660 × 4); 9 in. × 3 in., 880 ft ($\frac{2640}{3}$) and so on.

QUICK METHOD. The number of running feet of 1 in. × 1 in. in a standard = $165 \times 144 = 23,760$, which is 240 (or 1 per cent) short of 24,000.

Pence in £1 = 240.

∴ If a standard of timber cost £1 (240d) we could buy 100 ft 1 in. × 1 in. for 1d.

If it cost £48 we could buy 100 ft 1 in. × 1 in. for 4s; and if the section of the timber was 4 in. × 1 in. we could buy 100 ft for 16s.

Rule. Price per standard in £s gives price per 100 ft 1 in. × 1 in. in pence.

EXAMPLE. What is the cost of 200 ft 2 in. × 1 in. at £60 per standard?

$$100 \text{ ft } 1 \text{ in.} \times 1 \text{ in.} = 60\text{d} = 5\text{s}$$

$$\therefore 200 \text{ ft } 2 \text{ in.} \times 1 \text{ in.} = £1.$$

This method of pricing is 1 per cent against the buyer as it assumes that he gets 24,000 ft 1 in. × 1 in. instead of

23,760; it is therefore necessary to add 1 per cent to the cost. In the last example this would be 2·4 pence, so the final price would be £1 0s 2½d. Other aids in pricing timber are (a) the use of duodecimals and (b) the timber trade slide rule; the former will probably be a subject of study in mathematics, but the latter is quite outside the scope of this volume.

GLUES

Animal Glue. Bones, horns and hooves are boiled strongly in water to extract the glutinous materials from them, the mixture is strained and the water is boiled off, leaving the hard material which we know as slab glue. The material may also be obtained in small cubes and crystals.

In glue manufacture ordinary boiling would take too long for commercial purposes, so a pressure boiler is employed. We know that water boils at 100° C or 212° F (at ordinary atmospheric pressure). At a considerable height above sea-level, however, atmospheric pressure is smaller, and water boils at a lower temperature. Conversely, when pressure is increased on the surface of the liquid its boiling point is raised. For instance, at twice atmospheric pressure water boils at about 250° F.

A glue extraction boiler is designed with a lid which can be loaded; when heat is applied, therefore, pressure is built up inside and boiling takes place at a high temperature. In this way the process of extracting glue from bones is considerably speeded.

To make slab glue ready for use in joiners' work, it is broken up and soaked thoroughly in water before being heated (not boiled). This must be done indirectly through a water jacket to prevent the glue becoming overheated or burned.

Although glue is a messy material, cleanliness in its preparation is of utmost importance. Pots need boiling in a large container before a new batch of glue is prepared, and clean water only must be used to dilute it. The joiner usually thins the glue with water from the outer container, in which case the latter must also be scrupulously clean.

There are a number of alternative ways of heating glue besides that of the common gluepot. Usually the apparatus

takes the form of a water tank with holes at the top to receive several pots, the water being heated either by a gas burner, an electric immersion heater, or by steam pipes (calorifier). These elaborate methods have the disadvantages (a) that the glue cools more quickly whilst at the bench, (b) that hot water is not available for use at the bench, (c) the tank is liable to become encrusted with glue on the outside, and (d) the water is likely to become stale, because of the comparative difficulty of emptying and cleaning.

Animal glues have no resistance to moisture. In the same way that the slab is softened by soaking, so glue used on exterior work or other wet situations will soften and lose its adhesive properties. It is for this reason that lead paint is used in the joints of exterior door and window frames.

The holding power of glue relies upon its penetration of the wood cells on the surfaces being joined in order to obtain a grip or key. With animal glue, loss of heat causes it to gel (turn to a jelly). In this state its penetrative properties are lost. It is advisable therefore to use a different type of glue where there is likely to be a time lag between glueing and applying pressure.

Casein Glue. This glue is made from the solids in milk, and is purchased as a fine white powder. It is mixed with cold water to a stiff paste, which becomes less thick after half an hour, and is then ready for use. The mixture continues to be usable for some hours, and only sets hard on the wood after a lapse of about twelve hours. It is particularly useful for attaching large sheets of plywood to flush doors, a batch of a dozen being glued, piled and put under pressure together.

After a lapse of about four hours after mixing, casein glue becomes useless and must be discarded. For reasons of economy, therefore, only the amount likely to be used in that time should be mixed. Casein glue is strongly alkaline and reacts chemically with some woods, causing discoloration; it is therefore wise to experiment on a spare piece of the wood being worked, to determine whether special care is required.

Synthetic Resins. Glues in this category closely resemble natural resin, but are actually prepared by the chemical reaction of formaldehyde with urea (a substance found in animal urine).

Another chemical, known as the "hardener," is added when

this type of adhesive is used; and the whole process is carefully controlled for temperature, time and the degree of applied pressure. It is consequently only suitable for work in large factories, where special staff can devote all their time to mixing and issuing the glue and subsequently withdrawing stale batches.

Sythetic resins are a recent development and made the Mosquito aeroplane possible. They are waterproof, stronger than the wood itself, and have the property of effectively joining surfaces not in close contact. In practice $\frac{1}{20}$ in. is the largest gap which can be filled without loss of strength in the joint.

PLUGS AND FIXINGS

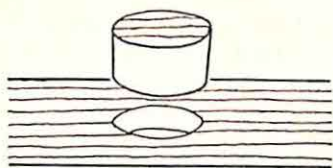
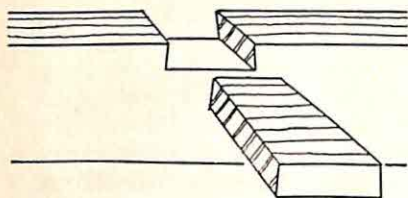
Plugging of Defects. In some timbers the knots are loose or resinous and must be cut out and replaced by pieces of wood the correct way of the grain. A round hole is most easily plugged; but if a different shape is required, the piece should be made first and a line drawn around it for removal of the defective part. The small pieces are often called "little joiners" (see Fig. 67).

Concealed Fixing. On work which is to be stained or polished, nail and screw holes are unsightly even when putty or other stopping is used. In long grained timbers a piece of wood may therefore be lifted with a small chisel while the nail is driven in, and afterwards glued down (Fig. 67).

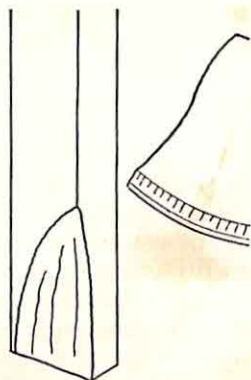
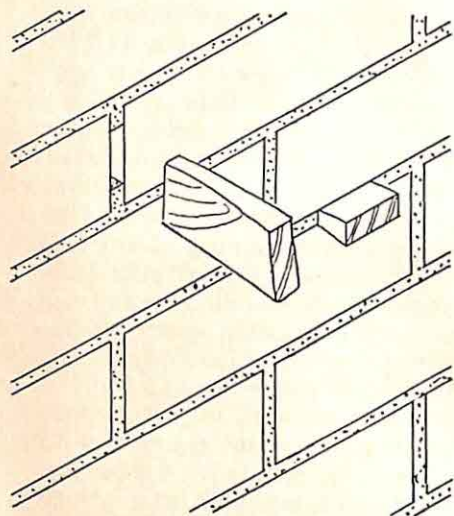
For screw fixing, a hole slightly larger than the screw head is made before the screw hole is bored. A round plug can be glued in after the screw has been turned home, and subsequently made flush with the face.

Bruises. Where wood has been bruised or dented, hot water is applied, to swell the grain. It often swells above the level of the wood; when dry it must be glasspapered flush.

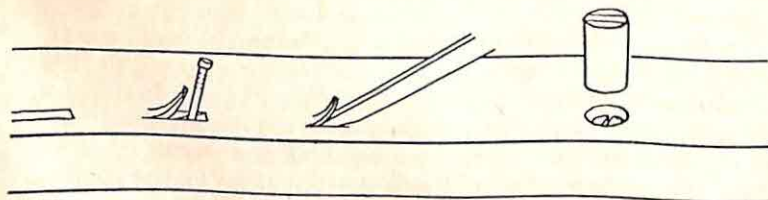
Brickwork Fixings (Fig. 67). Often cut nails driven into mortar joints or breeze blocks obtain a reasonably good hold. In other cases, however, and especially where screws are necessary, or hard mortar made with Portland cement turns the nails aside, wood plugs will be required. After careful selection of a position (to avoid disturbance of any bricks) a portion of the mortar joint is removed with a plugging chisel, and a piece of wood $\frac{1}{4}$ in. wider and thicker than the hole is



PLUGGING DEFECTS



WOOD PLUGS FOR
FIXINGS TO BRICKWORK



CONCEALED FIXINGS

FIG. 67. PLUGS AND FIXINGS

prepared. A twist is given to the plug by chopping diagonally opposite corners away with an axe (Fig. 67), and the plug is driven in and sawn off $\frac{1}{8}$ in. in front of the brickwork face (to avoid damaging saw teeth). A final blow or two sends the plug flush with the brickwork. The back end of the axe head should be used for hitting the plug, as the smaller round face of the hammer has a tendency to damage it.

If the brickwork is covered by plaster, the plugging chisel is replaced by an ordinary $\frac{3}{8}$ in. cold chisel, as this causes less damage to the plaster, especially as the hole may be in the brick itself.

Special Fixings. For securing fittings and furniture and for general handy use many special plugs are available, from about $\frac{1}{4}$ in. diameter upwards. These include "Rawplugs,"—a hollow fibre tube inserted in a drilled hole; "Plugit" plugs—hollow lead tubes with a rough sanded exterior; and "Philplug" a dry mixture of fibre and cement—wetted, rolled and forced into a drilled hole. All these are effective if of the proper size to fill the drilled hole neatly. In the two former instances the screw enters the hollow tube, expands it as driven, and produces a pressure and grip all round the circumference. "Philplug" acts similarly, the screw being started in a conical hole forced in the end by a special tool.

FASTENINGS

Bolts (Fig. 68). Temporary carpenters' work (e.g. sheds and hoardings) may require bolts, the *coach* bolt being preferred to the Whitworth (hexagonal head) by reason of the square shank which holds the bolt in position while the nut is tightened.

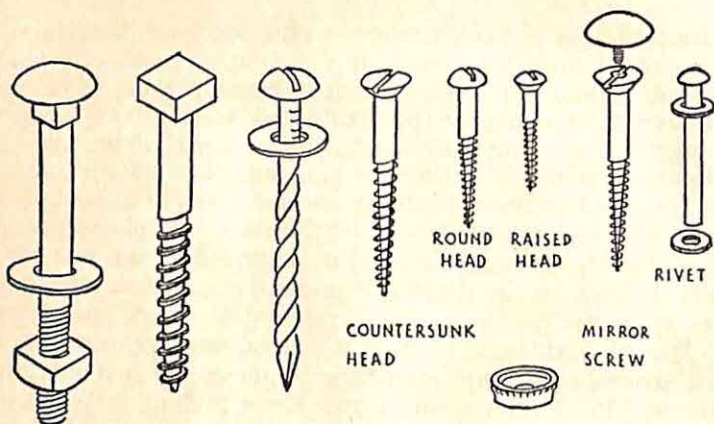
Where fixing is required from one side only, the *coach screw* is used.

For fixing corrugated asbestos, or iron, the *screwnail* is much favoured and is hammered in, twisting as it goes. It is galvanized.

Screws are made of iron or brass, and may be obtained with various platings, also black enamelled. Three shapes of head are in common use (Fig. 68) and the thickness of the shanks is denoted by numbers.

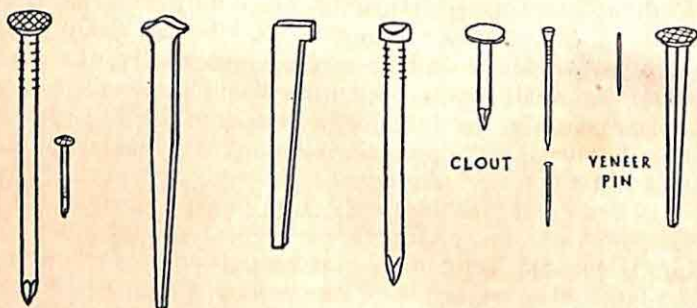
For fixing mirrors a detachable (screwed) dome head which is chromium plated is provided.

Screw cups are used to receive the screw head where



COACH BOLT COACH SCREW SCREWNAIL

SCREW CUP



ROUND WIRE

CUT NAIL

FLOOR BRAD

OVAL BRAD

CLOUT

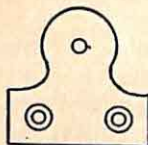
PANEL
PINS

YENEER
PIN

SLATING
NAIL



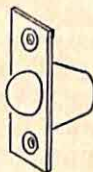
CORRUGATED DOGS



GLASS PLATE



BALES' CATCH



BALL CATCH

FIG. 68. FASTENINGS

removal and replacement would damage the finish, e.g. in access doors and traps, and loose glazing beads.

Rivets are useful for a movable joint, e.g. deck chairs. The end is burred over with a ball-pane hammer.

Nails (Fig. 68). Various shapes are used as follows—

Round Wire. Used for packing cases and other quick rough work. Very liable to cause splitting. Smaller sizes are used for fixing plywood, and other sheet materials.

Cut Nail. The carpenters' general purpose nail, parallel one way, tapered the other for half the length, must be inserted parallel to grain. The square end punches and tears the fibres of the wood in front of it and thus prevents splitting. Can be driven into lime mortar joints and provides a tenacious fixing.

Floor Brads. Somewhat similar in function to the cut nail; punched out of flat plate and tapered on one side only. The head has a single projection on one side.

Oval Brad. A better nail than the round wire type if there is a risk of splitting. The thin way goes along the grain.

Clout Nail. Is used for fixing sheet materials, like roofing felt, and the cords in sliding sashes.

Panel Pins. The joiners' nail, for fixing small mouldings and the like.

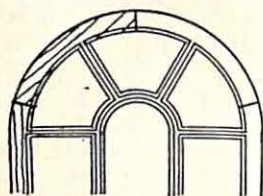
Veneer Pin. Is used only to position a sheet of veneer; it has no value for holding down, having no head.

Corrugated Dogs. Designed to pull joints together as they are driven in. Only used where they are concealed or where appearance is not important, usually mitres and butt joints.

Glass or Mirror Plates. Used for fixing light fitments to a wall. Two screws attach the plate to the cupboard, mirror frame, etc., and another to the wall.

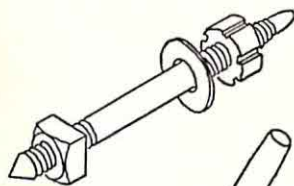
BOLTED JOINTS

Handrail Bolts (Fig. 69). Curved members usually need joining end to end, (a) to economize by reducing the amount of waste around the curves, (b) to avoid weakness due to the grain running across the member, (c) where curved parts join straight ones. Similar joints are needed where heavy members are mitred together, e.g. sills and heads to square or angular bays and lantern lights, joints in handrails, and fireplace curbs.

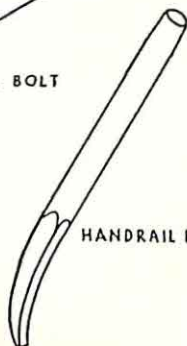


CIRCULAR HEADED SASH

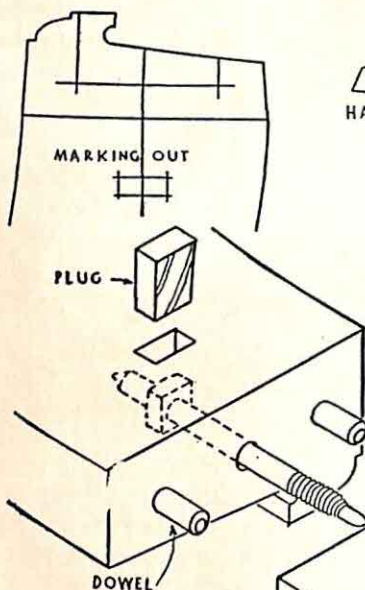
SILL FOR BAY WINDOW, CIRCULAR ON PLAN



HANDRAIL BOLT



HANDRAIL PUNCH



ASSEMBLING THE JOINT



SPLINED NUT
& WASHER

FIG. 69. BOLTED JOINTS

In all these cases the bolted joint is suitable and two dowels help to keep the joint in position and save it from twisting as the bolt is tightened. First the ends of the two members are carefully butt jointed and checked for line or angle. The two parts are held together while lines are drawn across the joint where bolt and dowels are to go, the marks are squared over and a line drawn parallel to the side with a marking gauge. The intersections are the centres for the twist bit which is used for drilling the holes.

It may be necessary to use a different method for marking out if members are moulded, e.g. handrails. Small panel pins can be driven into the end of one member, and by pushing the other up to it an impression is made. Black oilstone grease dabbed on the pin heads may help to make the impressions more easily visible.

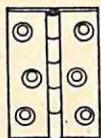
Now take the handrail bolt; screw the square nut right home, but the splined nut only just on to the full threads. Half the distance between the nuts is set back, from the joint to the nearest side of the slots which are to take the nuts, and the width and thickness of the slots marked, allowing for easy entry of the nuts. The slot for the splined nut needs to be an easier fit than the other.

When marking out is checked, form the slots by boring to the required depth, and finish with mallet and chisels. The holes may now be bored on the ends, checking for truth with a try-square on the face of the joint.

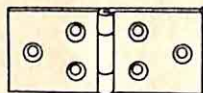
When assembling the joint, dowels are driven home into one side of the joint, cut $\frac{1}{16}$ in. short of the required depth in the other side, and chamfered for easy entry. The square nut is put in and the bolt turned right up, then the splined nut with washer put in and tightened with the handrail punch, at first by hand and finally with the hammer. The slots are filled with plugs of wood having the same direction of grain as the timber of each member.

IRONMONGERY AND FURNITURE

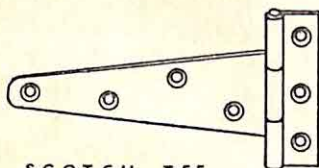
Cast iron, steel, and brass are commonly used in the manufacture of furniture and fittings. The processes involved include pressing and casting, the latter usually necessitating subsequent trueing by machinery. Upon the amount of accurate work put into the making, and to some extent upon surface



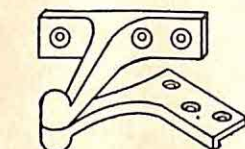
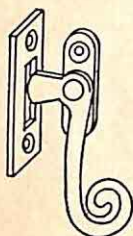
BUTT



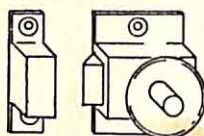
BACKFLAP



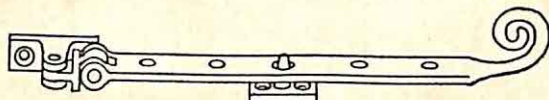
SCOTCH TEE



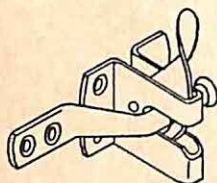
EASY-CLEAN CASEMENT
HINGE



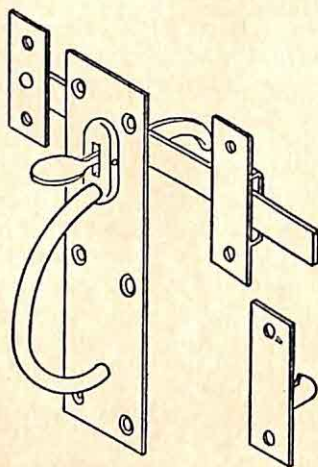
CUPBOARD CATCH



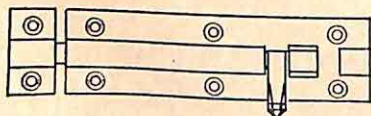
CASEMENT LATCH AND STAY



GATE LATCH

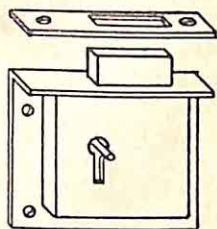


NORFOLK LATCH

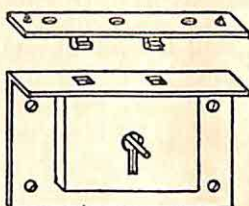


BARREL BOLT

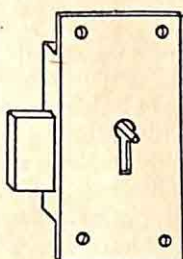
FIG. 70. HINGES, CATCHES, STOPS AND BOLTS



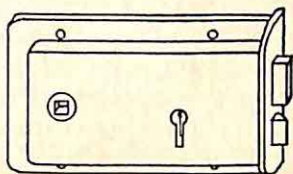
DRAWER LOCK



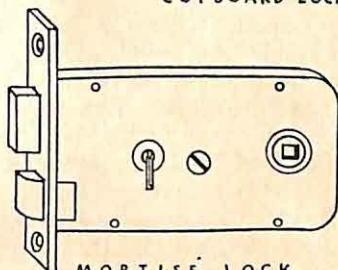
BOX LOCK



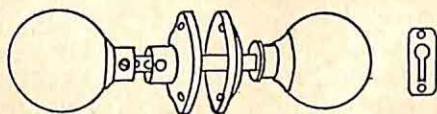
CUPBOARD LOCK



RIM LOCK



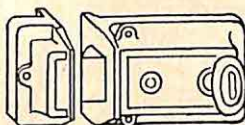
MORTISE LOCK



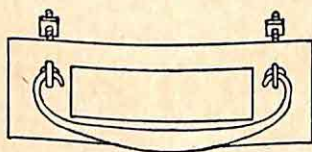
KNOB HANDLES, SPINDLE & ESCUTCHEON



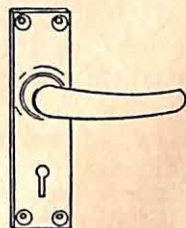
CYLINDER LATCH



MORTISE LOCK



POSTAL KNOCKER



LEVER HANDLE

FIG. 71. LOOKS AND FURNITURE

treatment and finish, will depend the quality and cost. Enamelling, galvanizing, plating, oxidizing and sherardizing are some of the finishes employed.

Butt Hinge (Fig. 70). The hinges most commonly used for doors and casement windows, fitting into recesses in the edge of the framing.

Backflap. Is used where a broader fixing is required than that provided by a butt. Usually screwed to the face of the framing.

Scotch Tee. Suitable for face fixing to light-weight ledged doors.

Window Cleaning Hinge. By reason of the offset pivot a casement sash fitted with these hinges swings outwards leaving a wide gap, thus making it possible to clean the outer glass face from inside the house.

Catches, latches, stays and bolts. These are suitably fixed with screws to the faces of opening components and their respective frames (see Figs. 68 and 70).

Locks (Fig. 71). In the case of drawer, box and mortise locks, the body of the lock is let into the material and, before forming the recess for the cover plates, a knife line is drawn round while the lock is in position. This precaution ensures a snug fit. Rim locks, cylinder latches, and cupboard locks are fixed directly to the inside face of the door, the latch in each case being operated by spindle and handles. To cover holes for keys and spindles, escutcheon plates and roses are fixed with small brass nails or screws.

Postal Knocker. The plate and flap serve to cover the hole in the door used for passing letters; the fitting is secured to the door by bolts and nuts.

Plastic Furniture. A cheap and pleasing substitute for metal in handles. These are in common use for the lever type of handle shown, with combined escutcheon and finger plate.

SECTION IV

GENERAL CONSTRUCTION IN JOINERY

THIS chapter deals with general principles and examples of construction and should be studied in parallel with the course of practical work. Although much of the detail is suitable for workshop practice, the amount which can be done in the time available does not permit of more than a limited choice of examples which can be added to, or taken in lieu of, the practical examples given in Section I. Such selection will vary with the teacher's views as to the order and difficulty of tool operations.

The subject-matter may be regarded as suitable for lessons in drawing and simple constructional technology, which form parts of most junior courses. The important factor is to establish, where possible, a scientific approach to the reasons for any operation, mode of construction, or selection of material.

As has already been said building woodwork is of two types, joinery and carpentry. Joinery in the broader sense, refers to the making (and often fixing) of all the woodwork in a building which is not primarily intended to carry weight. This includes doors, frames and linings; window frames and sashes; all wood finishings; stairs; cupboards, wardrobes and shelving; light gates and often posts.

Carpentry is concerned with the load carrying parts of a building. It includes beams and lintels; floor structures; roof framing; formwork for casting concrete to shape; and centers on which to build arches.

These are the main sections of woodwork with which the builder is commonly concerned: it should be noted that much standard joinery is now produced in large quantities by specialist firms; this is delivered on the site ready for fixing. In most house building schemes it is therefore found convenient for the carpenter working on the site to do the constructional work (carpentry) and to fix the joinery as and when required.

The following two sections deal with joinery and carpentry separately and in that order because we are most concerned at present with training in bench work of all kinds.

JOINTING

Edge Joints in Boards. The edges of two boards may be joined by one of several methods, so as to produce a wide board; in each case glue is used to make a permanent joint.

Butt Joint (Fig. 72). The edges of the boards are planed to fit. The operation is performed with a trying plane and the process is known as shooting. Such joints should be shot about $\frac{1}{100}$ in. hollow in the length of the joint. When glued and placed in contact the joint edges should be rubbed together by sliding one piece backwards and forwards to exclude surplus glue and bring the edges as close as possible. With the slight hollow, one cramp near the middle should be sufficient to keep the joint close until the glue is set. The efficiency of such a joint depends largely on the exclusion of air from between the glued surfaces.

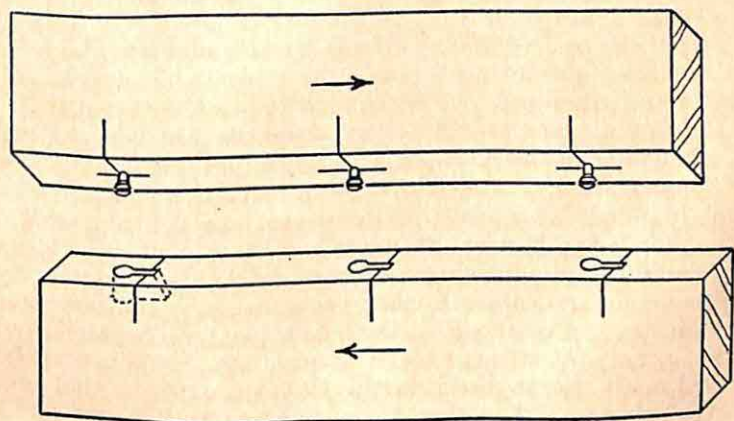
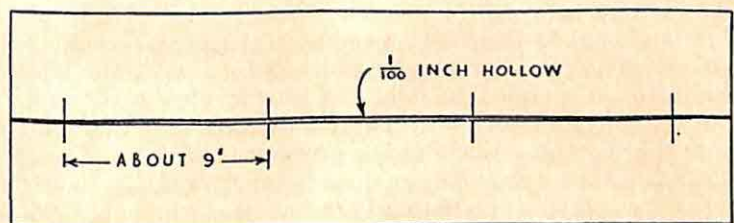
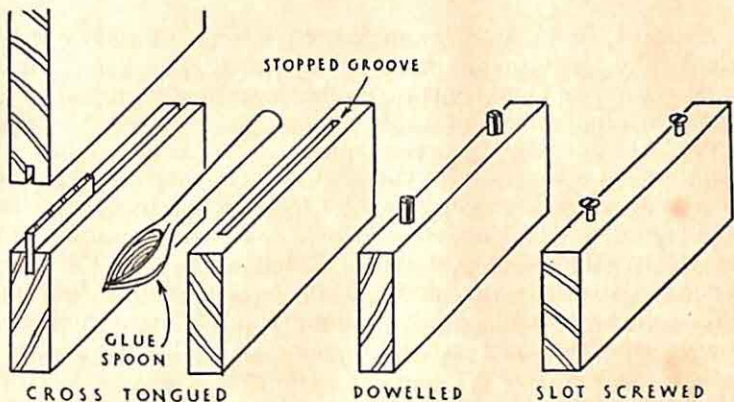
Cross-tongued joints are stronger than the above, and really need a glue spoon to get sufficient glue quickly into the grooves when assembling.

Dowelled Joint (Fig. 72). The joint is prepared as for a butt joint. Lines are drawn across the joint for dowel positions and carefully gauged from one side. Holes are bored and slightly countersunk. The dowels are glued into one side, cut $\frac{1}{8}$ in. short of the depth of the holes in the other piece and the ends chamfered (or rounded with a special bit) for ease of assembly.

The dowel rod should always have a slight flat or groove formed along its length before being used. This prevents air and glue being trapped in the hole and causing splitting.

Slot Screwed Joint (Fig. 72). Types of joint requiring glue may be impracticable on the building, and this joint is a good substitute. It draws and holds the two edges together.

The joint is shot and lines drawn across the face where the screws are to go. A gauge mark is made on both edges, and the screws fixed into one, leaving about $\frac{1}{2}$ in. standing up. In the edge of the other board holes are made very slightly larger than the screw head, and $\frac{9}{16}$ in. deep. Slots are now formed $\frac{3}{4}$ in. in length and $\frac{9}{16}$ in. deep. The joint is assembled and one board driven endwise while the other is held firmly. The countersunk screw heads bite into the sides of the slots and bring about a wedging action which pulls the joint tightly together.



SLOT - SCREWED JOINT READY FOR ASSEMBLY

FIG. 72. EDGE JOINTS FOR BOARDS

Battened Joint. Used as an aid to keeping flat wide boards which may have already been edge-jointed. The board must be free to expand and contract under the action of atmospheric changes in moisture content.

For this purpose the screw holes may be made elongated (another type of slot screwing) or grooved battens may be used to accommodate hardwood buttons. Table tops, drawing boards and notice boards are typical examples requiring this type of treatment.

Cleated Joints. Long counter tops which require jointing endwise are cleated to bring the joint tight. Cross-tongues or dowels may be used in addition to keep the two boards flush.

Corner Joints. Fig. 73 shows some types of joint which are used to join comparatively wide, thin wood at the corners when making box-like structures.

Tongued Joint. The groove which is formed at the end of one piece is intended to hold the tongue on the other. If, however, any side stress is put on the joint, it is liable to cause the short grain behind the groove to split away.

Nailed Joint. Suitable for quick, rough work like packing cases. By splaying the nails additional strength is obtained.

Rebated Joint. This is also nailed; any joint relying upon nails is relatively weak when pulled in a direction parallel to them.

Keyed Mitres. (a) The mitre is glued and when it is dry splayed sawcuts are made, into which pieces of veneer (thin hardwood) are glued.

(b) Sawcuts along the mitre are made, and the veneer glued in when glueing the joint.

Combed Joint. Parallel fingers lock together and the joint is usually glued. This joint used on boxes and delivery crates; it is intended to be machine-made and is quite effective.

Dovetail Joints. The best of corner joints. Used extensively by the joiner and cabinet-maker, occasionally by the carpenter (e.g. in gutter cesspools). Very suitable for the angles of drawers and other box-like structures. As the joint can be pulled apart in one direction only, it is arranged so that any stress will occur the other way. For example, a drawer is only pulled one way, and the dovetails are designed to resist the pull. There are several varieties, designed partly or

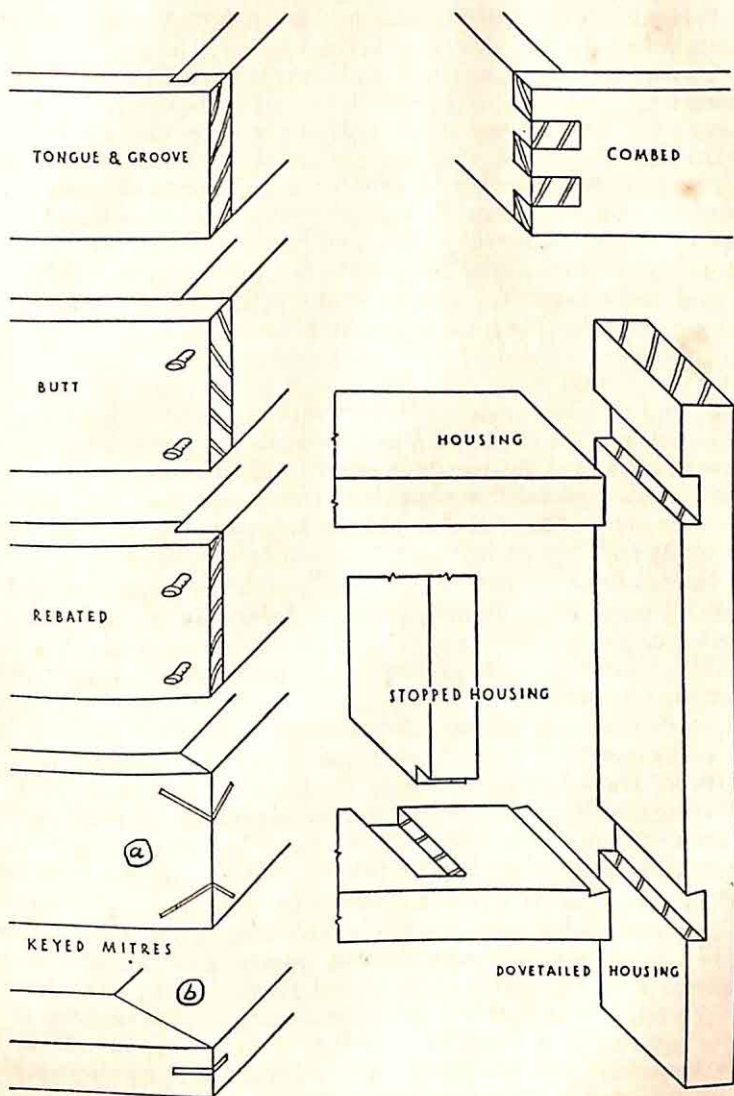


FIG. 73. CORNER AND HOUSING JOINTS

entirely to conceal the joint, and some are dealt with as practical examples in Section I.

Housing Joints (Fig. 73). These are two main kinds, both being suitable for joining the ends of shelves to the supporting end pieces, or for housing the ends of partition pieces into the shelves.

The square housing will need nails or screws to hold the joint together; where this fixing would be unsightly, the dovetailed housing may be used and will combine both functions.

If desired, either joint may be stopped short of the face of the work; by this means a better appearance is obtained, particularly on polished hardwood work.

DOORS

Doors of any kind are required to close a space—a room, a cupboard, a coal shed or tool house, etc. However it may be made, a door should be capable of remaining true (flat on the face) and should not alter its shape or size much under changes of weather.

Doors in general use are—

(a) *Ledged*—boards held together by ledges or battens on the face.

(b) *Framed*—a jointed frame or margin filled in on the face with boards.

(c) *Panelled*—a jointed frame filled in with thin panels grooved into the edges of the frame.

(d) *Glazed*—having panels of glass.

Note that (a) and (b) are commonly braced by diagonal members to prevent change of shape (see Fig. 81).

Panelled Doors. At this stage it is desirable to introduce the principles of construction for panelled doors.

The first point to consider is why panels are used. If a solid slab were taken out of a tree, reasonably dried and then used as a door, it would be found that in prolonged damp weather the door would expand and become too wide for the opening. In dry weather it might become too small and leave a wide open joint, because in dry air wood gives up its moisture and shrinks, the main shrinkage being across the grain. In either case, therefore, an inefficient door would result.

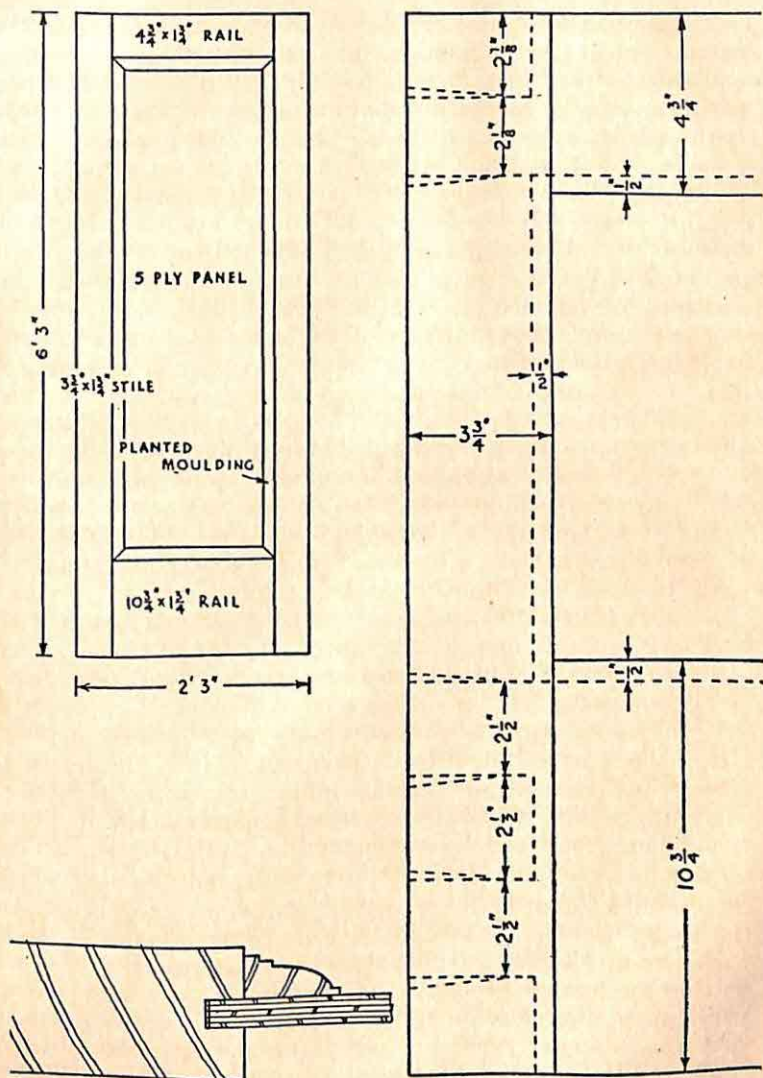


FIG. 74. FRAMED AND PANELLED CONSTRUCTION:
ONE-PANELLED DOOR

The object of panelling is to provide a comparatively narrow rim (called a frame) with well-jointed corners, which will change very little in size or shape. Within this frame a panel (or panels) can be inserted into edge grooves $\frac{1}{2}$ in. deep. If the panels are cut a little less than would fill the grooves, they can swell or shrink (expand or contract) with changes of moisture in the atmosphere.

Mortised and Tenoned Frames. Frames are fitted together by mortise and tenon joints of the haunched variety, as shown in Fig. 75. Variations in this joint are made according to the width of the tenoned piece.

The example in Fig. 74 is of the simplest form of frame used for a door to a room or closet, having one panel only. The frame consists of two stiles (out of 4 in. material) a top rail (out of 5 in.) and a bottom rail (out of 11 in.). The rigidity of the frame depends upon the width of the rails and the closeness of the joints at the shoulders. If a greater number of panels be used, cross rails would add to the stiffness of the frame when joints were glued and wedged.

Door Sizes. Doors are usually made to certain standard or recognized sizes, the height being commonly 4 ft greater than the width. Thus the sizes might be 7 ft $\times$ 3 ft, 6 ft 9 in. $\times$ 2 ft 9 in., 6 ft 6 in. $\times$ 2 ft 6 in., 6 ft $\times$ 2 ft. The larger sizes are suitable for entrance and main room doors; the smaller ones for less important rooms, stores and cupboards. The thickness of doors varies from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in. (nominal sizes), the most common being $1\frac{1}{2}$ in. and 2 in. (The nominal size is the dimension of the material before working.)

Jointing. The joints are haunched tenons. The width of a tenon should not usually be wider than $2\frac{1}{2}$ in. to $2\frac{3}{4}$ in. This avoids looseness developing through shrinkage and gives a tenon stiff enough to resist buckling when wedges are driven tightly on each side of it.

The haunching is the short stump of the tenon left on when cutting the tenon to width; the haunch fills the panel groove, which must therefore be run through to the end of the stile. The haunching serves an important purpose though; if properly fitted it prevents any twisting of the rail and keeps the faces of the door flush near the outer edges of the top and bottom rails. It also prevents an opening being formed if the stile shrinks away from the shoulder of the tenon.

The bottom rail being very wide has two tenons formed on the end with a haunch between them in addition to the outer haunch. All wide rails are treated in this way.

Panels. Panels may be of solid material $\frac{1}{2}$ in. or more in nominal thickness and made from two or more pieces edge jointed; or they may be of plywood, in which case five-ply is used (see Section III). Plywood, being crossed layer by layer in direction of grain, is not subject to much change of size and is strong and rigid if $\frac{5}{16}$ in. or more in thickness.

Sizes of Members. The market sizes of timber have an important influence on the sizes of the members in a standard door. Generally, a door which is specified as 2 in. thick, will be cut out of material 2 in. $\times$ 9 in. If a rail from this be planed all round, it will finish about $8\frac{3}{4}$ in. $\times$ $1\frac{3}{4}$ in. For stiles and top rail a plank 2 in. $\times$ 9 in. is usually ripped down the middle; the machine cut will be about $\frac{5}{16}$ in. wide, so that each piece when planed is about $4\frac{1}{4}$ in. $\times$ $1\frac{3}{4}$ in. In the case of a single panelled door (Fig. 74), better proportions are obtained by making the top rail 1 in. wider than the stiles, which can be sawn 4 in. wide out of 2 in. $\times$ 8 in. material.

FOUR-PANELLED DOOR CONSTRUCTION. The older type of four-panelled door is typical of good and well-arranged door design and construction. It contains and illustrates all the joints which can occur, and is therefore given here as an approved framing example which can be varied in many ways in regard to proportion and the disposition and number of its panels.

Fig. 75 shows the framing details. The additions to the previous example are: a middle rail (also called a "lock" rail) dividing the height into two panel lengths, and vertical members, called muntins, which divide the width into two panels. This sub-division, in days before plywood was known was a great advantage, because the liability to shrinkage was reduced as the width of the panel was reduced.

With the old style of door lock and knob handle, it was usual to fit the lock through the stile and partially into the lock rail. If "single" tenons were used with a haunch between (much as for the bottom rail) the insertion of the lock removed the core in the stile between the tenons. To avoid this "twin" tenons were often adopted and are shown here. (These are too difficult to use as a practical workshop example at this

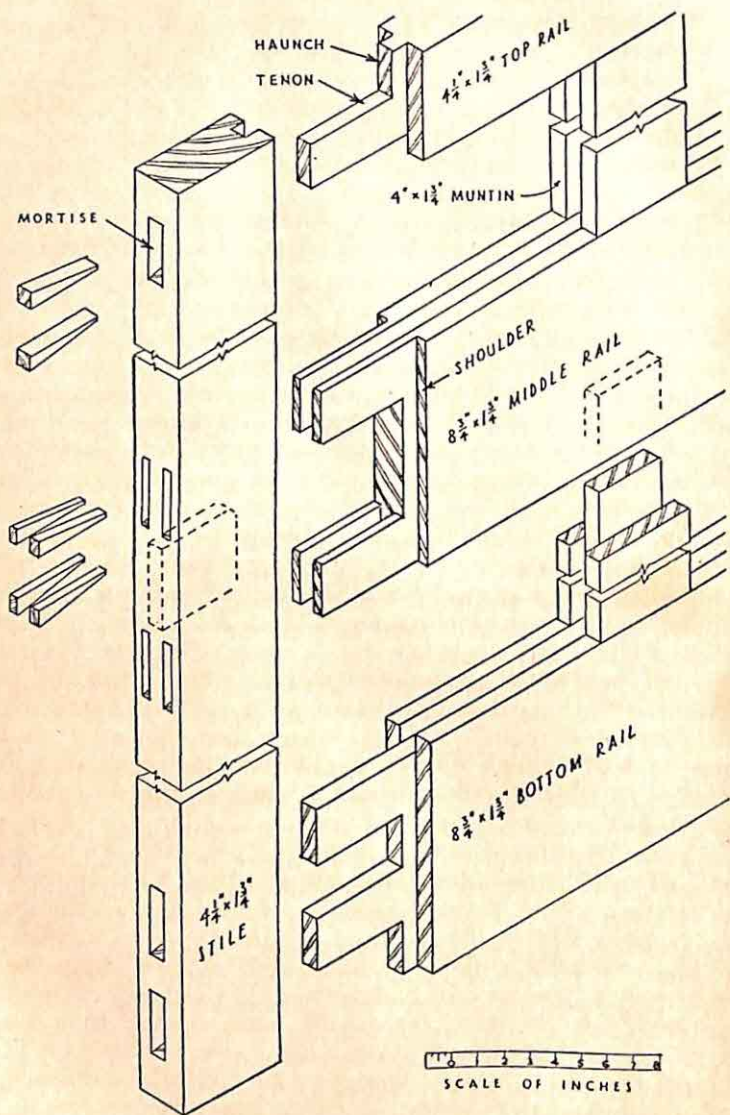


FIG. 75. FOUR-PANELLED DOOR CONSTRUCTION

stage of training.) When the mortise lock is fitted into the centre of the thickness of the door, the joints are not cut away nor exposed. Note that the tenons are narrow in order to leave plenty of space for the lock; that, if an ordinary rimlock (fixed on the face) be used, two single tenons would be employed.

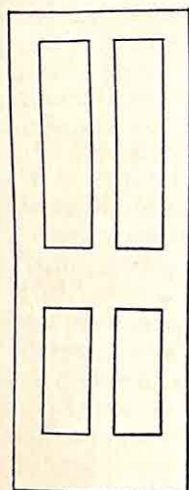
Muntin Joints. The tenons to the muntins are left the full width remaining after grooving their sides to receive the panels. The muntins are not designed (and are not required) to hold the framing together, and it is of no consequence if the tenons shrink in width. As these joints are not to be wedged, they are formed with short (stump) tenons and are driven close when assembling by wedging the top and bottom rails inwards with the first wedges driven.

Internal Doors. *Design* (Fig. 76). Bearing in mind the principles of construction discussed elsewhere there is a wide choice of designs, fitness for the particular purpose being a factor to consider.

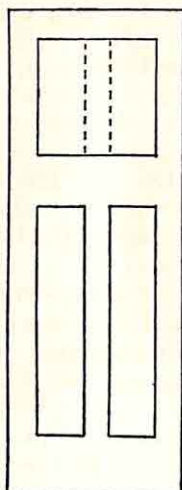
The simple square framed four-panel door may be varied by having the middle rail above or below the centre. This rail provides a broad fixing for the lock, and an advantage of having it above centre is that the lock is out of reach of toddlers.

Several arrangements and numbers of panels may be used, and the alternative sections may be combined with the majority of designs to provide a variety of doors suitable for most purposes. Single-panel and flush doors are made possible by the development of modern materials like plywood and block-board, which have the great advantage that no matter how large the piece, expansion and contraction due to change of moisture content are negligible.

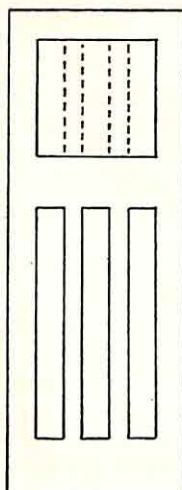
The use of elaborate mouldings is rapidly declining, but a restrained use of those having a simple outline is still advantageous where added grace or dignity is required. As an instance of this, doors to banks and civic buildings are given a solid appearance by the use of bold mouldings. The modern tendency, however, is to rely more on the beauty of the wood itself or on some special decorative surface treatment as an added interest to joinery work; this is made easy by the newer materials, which form a groundwork for beautiful veneers covering large areas without the need for elaborate framing and fixings. Only one type of glazed door is illustrated,



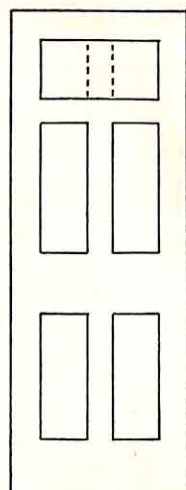
4 PANEL



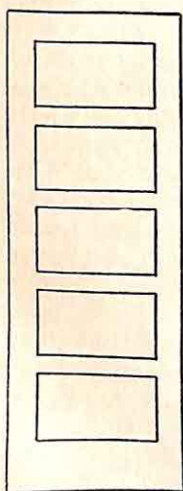
3 OR 4 PANEL



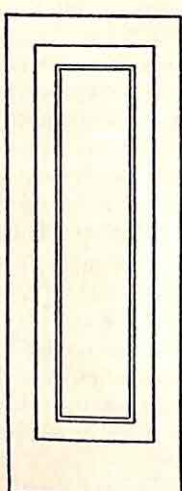
4 OR 6 PANEL



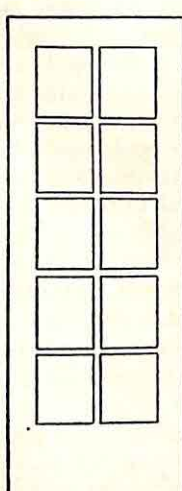
5 OR 6 PANEL



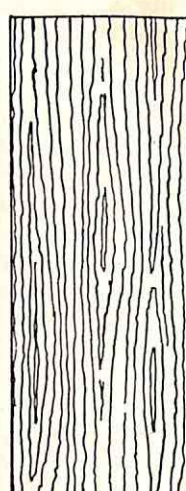
5 LAY PANELS



SINGLE PANEL



GLAZED



FLUSH

FIG. 76. TYPES OF INTERNAL DOOR

but a little thought will show that several alternatives are possible; for instance, a single large panel or five lay panels, and many others. These doors are used internally to convey light from one room to another or to a corridor; or in a vestibule.

The flush door now in general use, usually consists of a skeleton framework either "dogged" together or framed like a panelled door, with a skin of three-ply glued on each side. The edges of the plywood have not a particularly pleasing appearance, hence an edging is usually put on the outside of the stiles, and occasionally all round.

Mouldings. These may be *stuck*, i.e. worked on the solid material; *planted*, i.e. fixed on the surface; or *bedded*, i.e. tucked into a corner. A *bolection* moulding is one which stands out from the face of the framing. Fig. 77 show sections through various types of door construction.

Usually panel pins are used for fixing loose mouldings, the holes left after punching them in being filled—with putty if the work is to be painted or with suitably coloured hard stopping for varnished or polished work. For concealed fixing, one side may be screwed from the back, and another moulding fixed with pins used to cover these fixings.

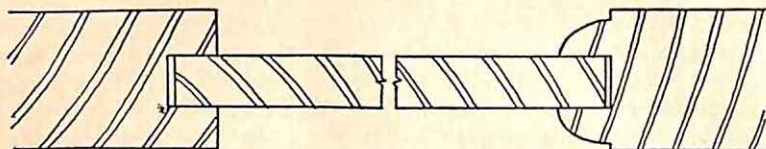
Gates. It is probable that, on the average, no item of timber construction gives more trouble in use, nor so often fails, as the ordinary outside gate. Rain, wind and sun catch it at all angles; and its occasional use as a seat, swing, or climbing frame makes it necessary to give careful attention to its initial construction and fixing. It would be an excellent exercise to write down all the faults which have been found in gates, and then to determine how many could have been anticipated and prevented and by what means.

Some common failings are—

- (1) Scraping along the ground; may be due to the gate distorting and dropping at the outer edge, or the posts toppling.
- (2) Ineffective catch; may be due to the same causes or to unsuitable design of the catch.
- (3) Rotting of posts or gate.
- (4) Twisting of the framing.

Bearing these points in mind, consider what should be done to ensure a sound job.

Posts. Due to alternate conditions of soaking wet and subsequent drying, these frequently rot at ground level; the

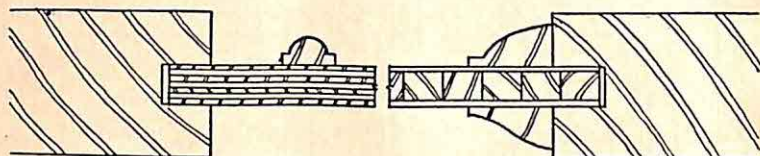


SQUARE FRAMED

SOLID

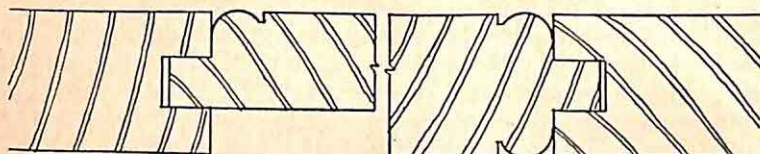
PANEL

SOLID MOULDED



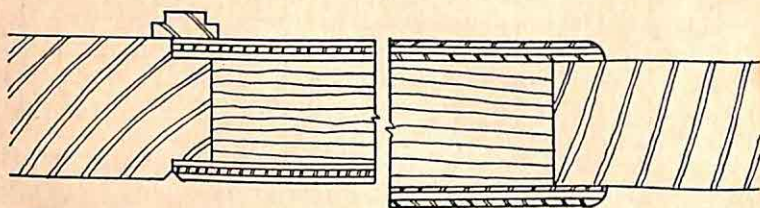
PLY PANEL, PLANTED MOULDING

BLOCK-BOARD PANEL, BED MOULDINGS



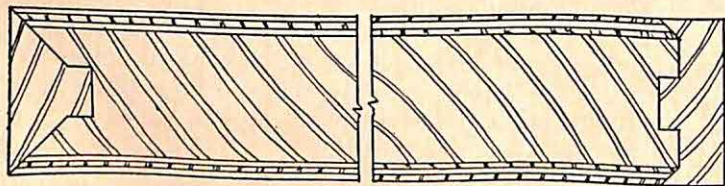
BEADED PANEL

SOLID DOOR (FIRE-RESISTING, IN TEAK)



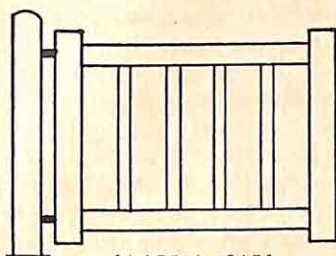
PLY FACED

RAISED PLY FACE

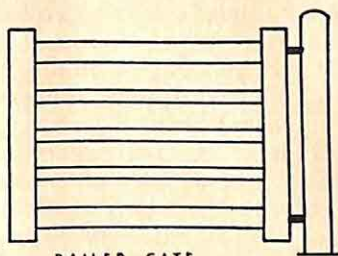


FLUSH DOORS - ALTERNATIVE EDGE TREATMENT

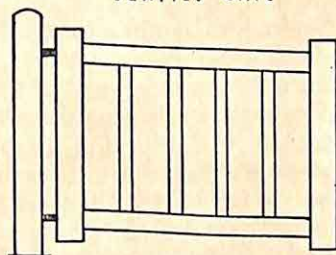
FIG. 77. ALTERNATIVE DOOR SECTIONS



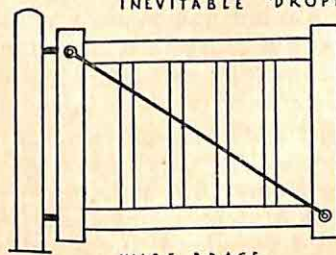
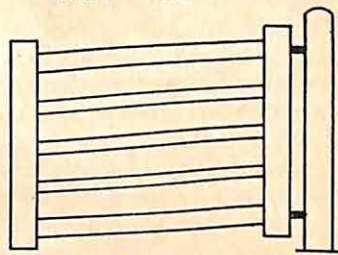
SLATTED GATE



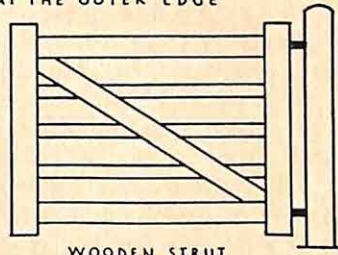
RAILED GATE



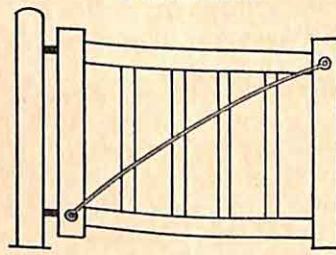
INEVITABLE "DROPPING" AT THE OUTER EDGE



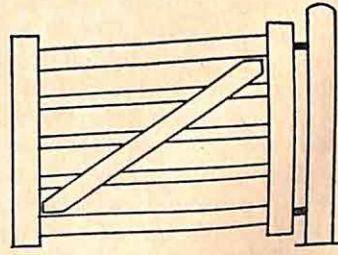
WIRE BRACE



WOODEN STRUT



INEFFECTIVE BRACE



INEFFECTIVE STRUT

FIG. 78. GATES: GENERAL PRINCIPLES

condition being aggravated by insect attacks. Oak posts are more resistant than deal, and to increase their resistance the timber should be impregnated with creosote under pressure or charred in a fire to a point 6 in. above the ground level. A sufficient depth to sink the post if in fairly firm ground is 18 in. (deeper for very heavy gates), the hole being 6 in. deeper and hard-core put in for the post to rest upon. Concrete 4 in. to 6 in. deep should be put round the post and finished above ground level with a downward and outward slope to prevent water lying there.

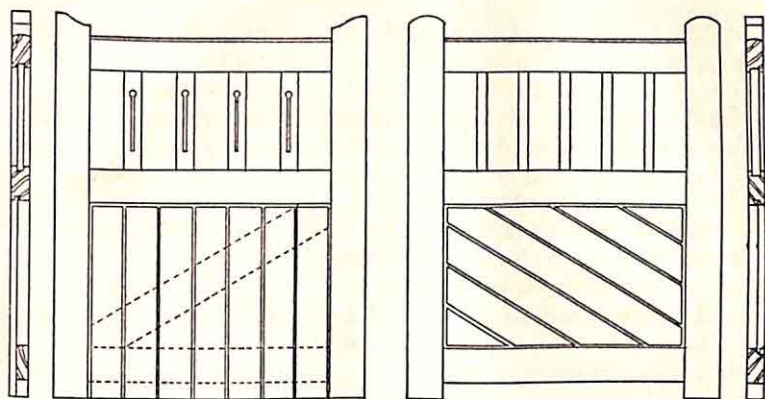
Brick piers are most suitable for use in conjunction with brick boundary walls, if they have adequate foundations to prevent uneven settlement and if the hinge pins are built in as the work goes up.

Sizes. The single gate is usually 3 ft wide while double gates for garage entrances should be at least 6 ft wide; in some places 7 ft 6 in. is compulsory, to avoid a car having to swing at too wide an angle on to a busy road.

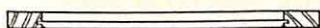
Design. Take a piece of wood or a book to represent the gate and, gripping between thumb and fingers by one top corner, try to hold it steadily in position. Again try holding a 7 lb weight at arm's length. Both feats will prove difficult—not because the objects are particularly heavy but because the weight is not in line with the supporting member. Wide, heavy gates may have a wheel and track at the outer edge; but a good method for small ones is to support the weight at the outer edge by means of a diagonal strut or a brace. A strut will run from the top outer corner to the lower inside corner and will be in compression; a brace will run across the other diagonal and will be in tension. Of the two the strut is most suitable for timber construction; it must run the right way to be of any use (see Figs. 78 and 79).

Construction. Mortise and tenon joints would be used. The tenons may run through and be wedged, or may be stump tenoned (not passing through); in either case insert hardwood pins near the shoulders. Glue is not used, but joints and any parts which will be covered are painted on assembly.

Stump tenons obviate a common source of trouble, i.e. exposed ends of tenons; end grain absorbs water freely and in addition the tenons may shrink in dry weather and allow moisture to get in and start rot. Slats (Figs. 78 and 79) may be fixed



BRACED FRAME

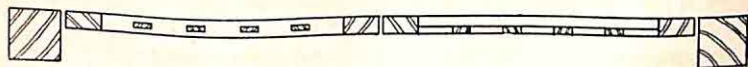
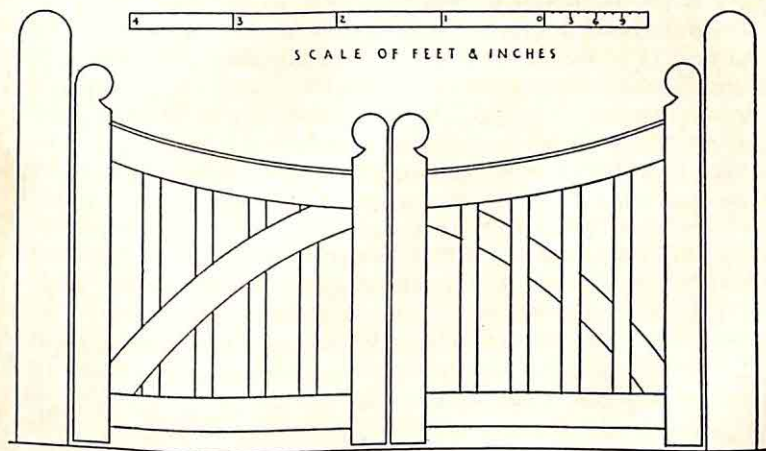


SINGLE GATES

BRACED FILLING



SCALE OF FEET & INCHES



DOUBLE ENTRANCE GATES

FIG. 79. FRONT ENTRANCE GATES

with galvanized nails where they run across the faces of rails, or housed in shallow mortises where they form a part of the framework. Struts need to be tenoned or housed into shallow mortises to keep them in position; when the gate is hung the tendency for it to drop at the outer edge will keep the shoulders of the struts tight, so no additional fixing is required.

If the filling is of tongued and grooved boarding it may be placed diagonally in which case it acts as a strut provided it runs in the right direction.

Fixing. At least a $\frac{1}{4}$ in. space should be allowed at the vertical edges and 1 in. at the ground. Rebated meeting stiles are not advisable, being a continual nuisance due to the gates expanding and contracting with the weather.

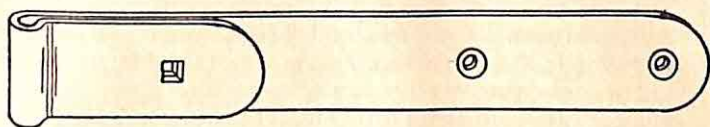
Hinges and Furniture. Heavy type hinges which can be oiled or packed with grease are preferable to the thin sheet variety (garnets). For brickwork fixing, hinge pins which can be built in are the best.

The catch should have an easy action to enable the gate to fasten itself; a spring may be used to aid return to the closed position or the hinges may be fixed slightly out of plumb so that the gate opens "uphill" and tends to run back when released.

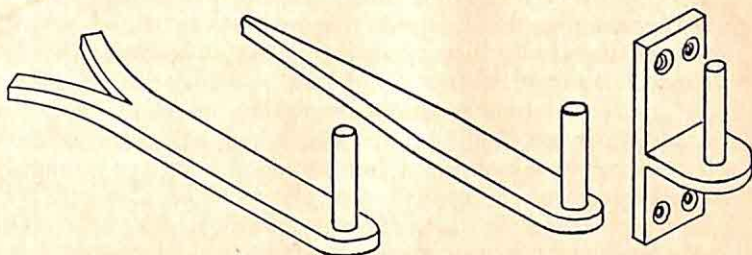
Every ironmongery store will stock ready-made hinges and a variety of latches for gates, beautifully finished with black enamel or zinc plating (galvanized). If we take the trouble to study these fittings after use, in varying stages of wear, it will become clear that their construction is too flimsy for the hard (and all too often, unfair) treatment with which they must contend.

On the other hand fittings made to order by a blacksmith can be seen, particularly in country districts, so sturdy and simple in construction that the heaviest work is borne without signs of impaired efficiency.

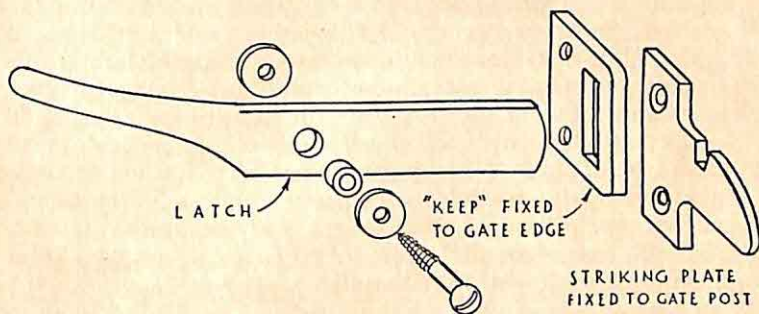
It is an interesting pursuit when out walking to take note of the more satisfactory fastenings; a quick sketch made at the time will help to refresh the memory for purposes of drawing and possibly making at a later time. Some novel and, to an appreciative craftsman, really delightful ideas are to be found on railway properties. The reason lies in the fact that railway companies encourage all employees to make suggestions for improvements, and that large numbers of blacksmiths are



STRAP HINGE 12" LONG OUT OF 2" $\times$ $\frac{1}{8}$ " MILD STEEL



HINGE PINS FOR FIXING TO BRICK PIER OR WOOD POST



COMBINED GATE STOP
AND STRIKING PLATE
WITH FISHTAILED END
FOR BRICKWORK FIXING

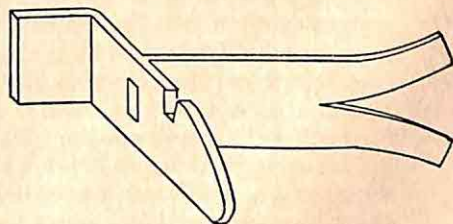


FIG. 80. GATE FURNITURE

employed to make every kind of ironwork. In addition, everything is made to last as long as possible, thus saving frequent and expensive renewals.

The furniture illustrated in Fig. 80 is of simple sturdy type, easily made with the simplest equipment from mild steel bar and rod. It is intended to illustrate the practical design of gate furniture, and to provide a starting point for your own researches into the subject.

The strap hinge is a length of 2 in. $\times$ $\frac{1}{8}$ in. mild steel bent while red hot around a steel pin and clamped tight in a vice. The square hole accommodates the square shank of a coach bolt and the two countersunk holes take ordinary countersunk-head iron screws.

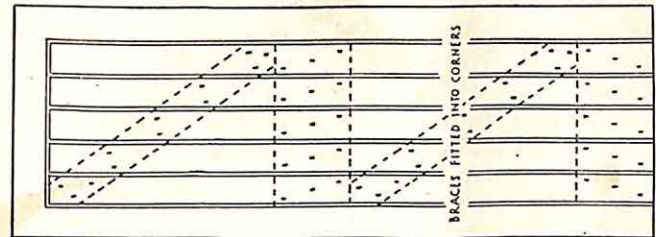
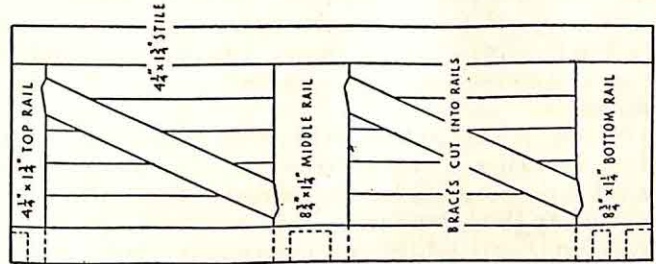
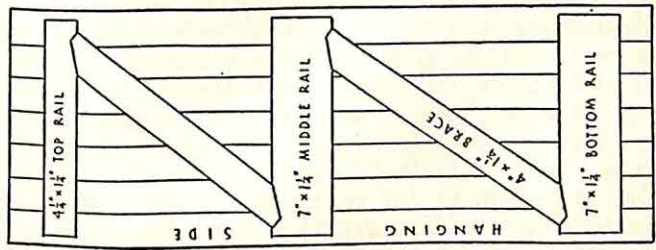
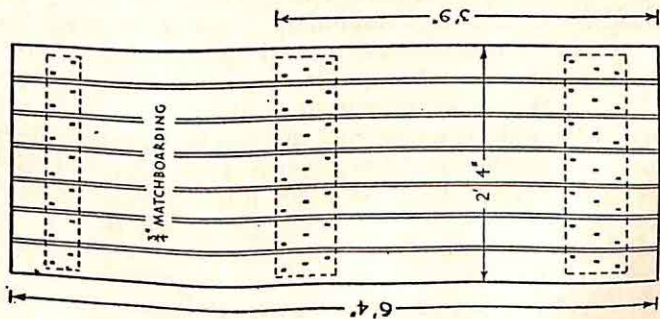
Hinge pins with fishtailed anchors are most efficient, being built into the brick pier or grouted into a joint afterwards. The pointed kind is hammered into a hole in a timber post, and the flat plate type screwed to the face or let in flush.

The function of a latch is to clip the gate shut, however casually it is shut or banged. This is best achieved when the striking plate has a long shallow slope to bring the latch to the slot position. The lever portion must be heavier at the latching end than at the handle end, so that it drops into the slot, and it must be sturdy enough to resist bending should the gate drop. It would be a good exercise to design a set of furniture which would allow of easy adjustment against this contingency.

Side Entrance Doors. *Ledged Doors* (Fig. 81). For side entrances, and for other outside access (e.g. to coalhouses), a simple door is quickly made by putting a number of tongued and grooved boards together and nailing to rails or ledges. Cut nails are best for the purpose and may be longer than actually necessary; the ends which come through are clenched over, thus giving added anchorage for the boards.

When constructing these doors, the ledges are placed on a bench and two nails put in each to hold them temporarily while the boards are nailed on. This done, the temporary fixings are removed and the ends of the door sawn true.

Ledged doors will inevitably drop at the outer edge, the weight of each board causing a downward sliding action which is resisted only by the nails. Ledged doors are therefore not very satisfactory in use; they need some definite resistance



LEDGED DOOR

LEDGED & BRACED

LEDGED BRACED & FRAMED

FIG. 81. SIDE ENTRANCE DOORS

against droop, which is provided in the ledged and braced type.

The same procedure as before is followed when making this type of door and the braces put in as a last operation. Mark their positions $1\frac{1}{2}$ in. to 2 in. in from the end of each rail; then place them in position, mark the length, and square the abutment with a try-square to a depth of 1 in. to $1\frac{1}{4}$ in. Join the intersection of the edges and cut the braces.

Set the braces in position and mark the recesses in the rails around their ends with a pencil or marking knife. The recesses may be carefully removed by paring vertically with a bevel-edge chisel. The braces are then forced in tightly and nailed from the boarded side.

When hanging the door, it is essential that the braces run from top outer edge to inside lower edge (hanging side), then the weight of the outer part of the door is effectively transferred by the brace to the hinged side. The so-called braces are then in compression. A more accurate description of these members would therefore be "struts."

Framed, Ledged and Braced Door (Figs. 81 and 82). A superior door for use in outbuildings, is the framed, ledged and braced door in which a braced (strutted) frame is filled in with boards. It should be noted that the ledges are on the inside and the outer face is flush, being particularly suitable therefore for throwing off driving rain.

The outer frame is made of 2 in. stuff, the middle and bottom rails of $1\frac{1}{4}$ in. stuff, having their tenons flush with one face ("barefaced" tenons Fig. 40). The boards may be put in place before fixing together or be slid in from the bottom afterwards. Glue is not used; but all joints, including tongues and grooves, are painted with a good lead paint and pinned. The braces may be cut and fitted as described above, or alternatively they may be cut to fit closely into the angles between stiles and rails. The first method is the more reliable, the other tending to force the joints apart; should one joint open, through pressure or shrinkage, the braces become less effective.

Front Entrance Doors (Fig. 83). *Design.* This is influenced by the several functions which a front door is required to fill. Besides being in continuous use as the main door of the house, it is required occasionally to pass large furniture and

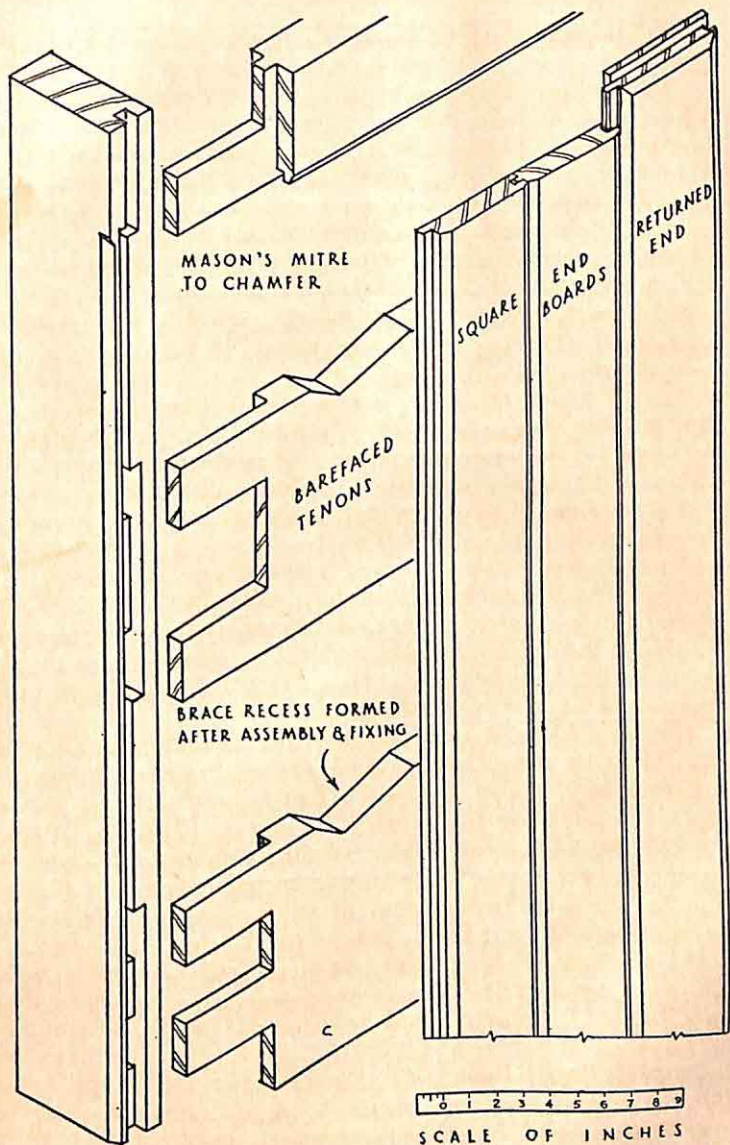


FIG. 82. FRAMED, LEDGED AND BRACED DOOR CONSTRUCTION

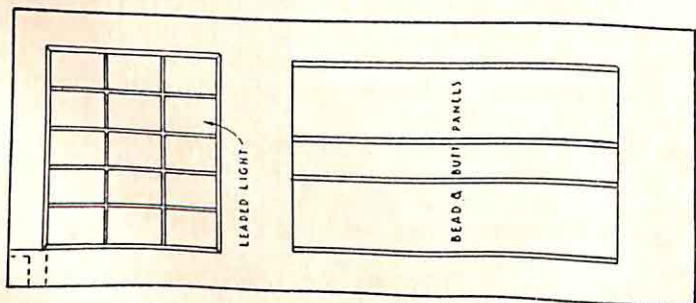
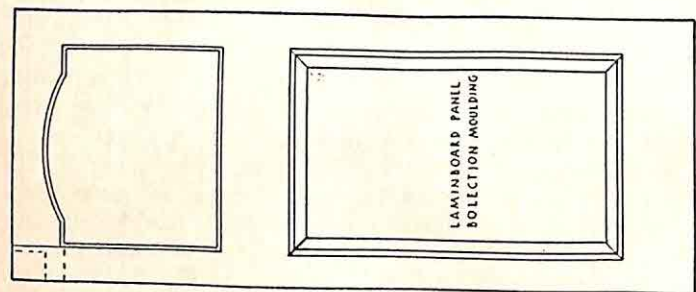
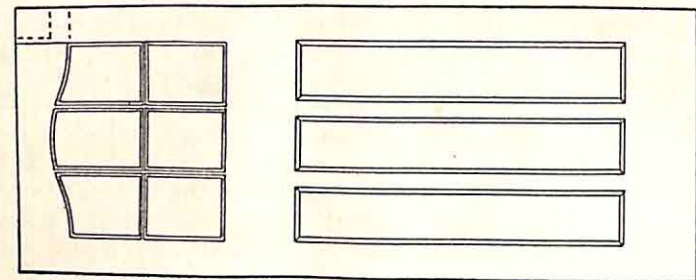


FIG. 83. FRONT ENTRANCE DOORS

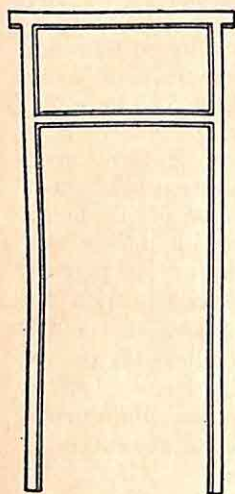
will be wider than the other doors; 2 ft 8 in. $\times$ 6 ft 8 in. is used for the normal house, but a house having rooms capable of taking large furniture may need up to 3 ft $\times$ 7 ft. Such doors are usually thick in proportion (normally 2 in.) and of sturdy construction to exclude burglars, the front door being the usual point of entry. If glass panels are used they should be small, and the glass should be of the heavy obscured type so as to withstand the occasional banging of the door due to a through draught. Leaded lights are a pleasing alternative. The front door is a feature which gives the visitor his first impressions of a residence, consequently raised and fielded panels, mouldings and other devices are at times used to lend added grace and dignity. The relatively high middle rail is in modern use, and serves the useful purpose of making the upper glazed portion proportionately smaller.

Construction. This is much the same as for other doors, but curved rails introduce more difficult joints and moulded work. Special planes known as thumb planes (small moulding planes) are used, and since they are not always the exact shape of the moulding being made, a scratch gauge can be used to impart the correct outline before glasspapering. A scratch gauge is a tool which the joiner makes for himself and consists of a piece of hardwood sawn down the middle into which a scraper of the required shape can be fitted and secured.

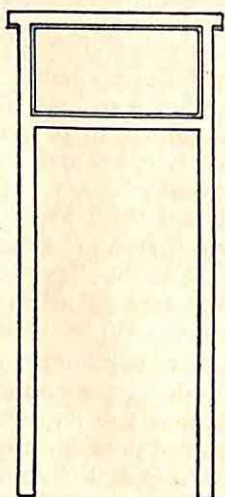
Regarding the third type of door shown in Fig. 83, when the main part is ready and fitted together, the glazing bars should be marked to the exact length at the shoulders to fit the curved portions, then cut and fitted. As the moulding shows on the outside of the door, putty may be put on the inside for glazing; but a much neater method is to use glazing beads. These may be fixed with panel pins, but on superior hardwood work brass cups are let in to receive brass screws. Repairs are thus made easier and the removal and replacement of screws is less damaging to the door.

Door Frames and Linings. The wood frame or surround to which a door is hinged may be either a stout frame set within the brickwork or a comparatively thin lining made to cover the edge of the surrounding brickwork as well as to receive the door.

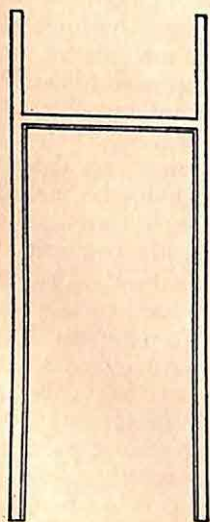
Door linings are used chiefly for inner doorways in brick walls; they are nailed to wood plugs in the jamb of the doorway



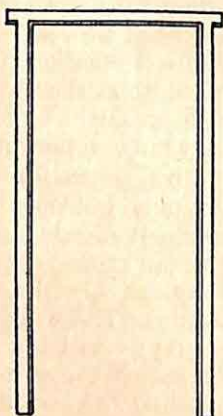
DOOR & FANLIGHT
OPENING TO ONE SIDE



DOOR & FANLIGHT
OPENING OPPOSITE SIDES

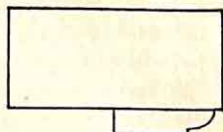


INTERNAL FRAME WITH
UPPER FLOOR HOLD

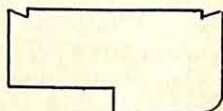


ORDINARY INTERNAL
OR FRONT ENTRANCE

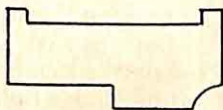
FRAME SECTIONS



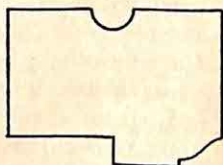
SQUARE FRAMED WITH
PLANTED DOOR STOP



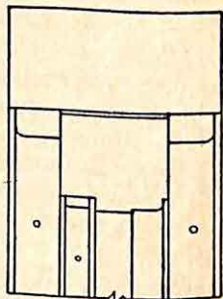
SOLID REBATED & MOULDED
GROOVED FOR PLASTER



INTERNAL FRAME
GROOVED FOR SLAB WALL



HEAVY FRONT ENTRANCE
WITH MORTAR GROOVE



BORROWED LIGHT

FIG. 84. DOOR FRAMES

and do not stand independently. Door frames are used for openings in light partitions (other than wood) and for external doorways; the frames are stout enough to stand independently but are secured by anchors, or plugs and nailing.

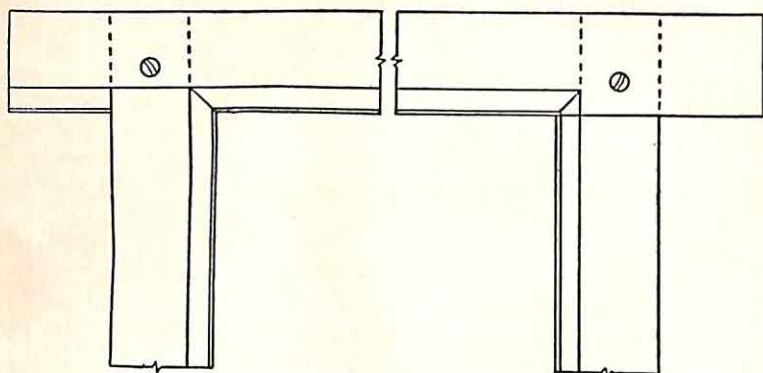
Linings are tongued together and nailed at the angles (Fig. 89). Frames are mortise and tenon jointed, wedged and pinned (Fig. 85).

Some linings are rebated (square sunk) on both edges, particularly in good work, but frames are single rebated (one edge only) unless a fanlight is to be used opening the opposite way to the door. Where there is need, the lining may be built up as shown in Fig. 89 instead of being cut from the solid as in Fig. 88. The projecting portion of the lining, called the stop (see Fig. 87), may be nailed on as an alternative construction; in this case it is often fixed accurately in position at the time the door is hung.

Construction of Door Frames. The construction varies with the section of the frame and its arrangement. If fanlight sashes (Fig. 86) are to be provided they may be (a) permanently fixed, (b) made to open on the same side as the door, or (c) made to open on the opposite side to the door; the method of arranging depends on the use of the fanlight. Generally fanlight sashes are used above front entrance doors to transmit light to a hall or passage when the door is not glazed, but they may also be used to light one room or corridor from another. The latter type is known as a "borrowed light" since it borrows the light it transmits from a room having direct external lighting.

Glazing may be done direct into the head of the frame if desired, when the fanlight is not required to open.

Since the mortise and tenon joint is used, and the tenons are short ones, wedges are not very effective in holding the joints permanently, especially where the atmosphere is damp; hence $\frac{3}{8}$ in. dowel pins are put right through each joint, about $\frac{1}{2}$ in. from the shoulder of the tenon (see Fig. 85). If the hole in the tenon is made slightly nearer the shoulder than the hole in the frame, and the dowel is pointed before driving, the joint will be drawn up tight. Another method is to use a steel draw-bore pin to draw the joint tight first. The pin is tapered (Fig. 86) and can be tapped back after the operation; on withdrawal a wooden pin is inserted and driven home.



MITRED JOINT

MASON'S MITRE

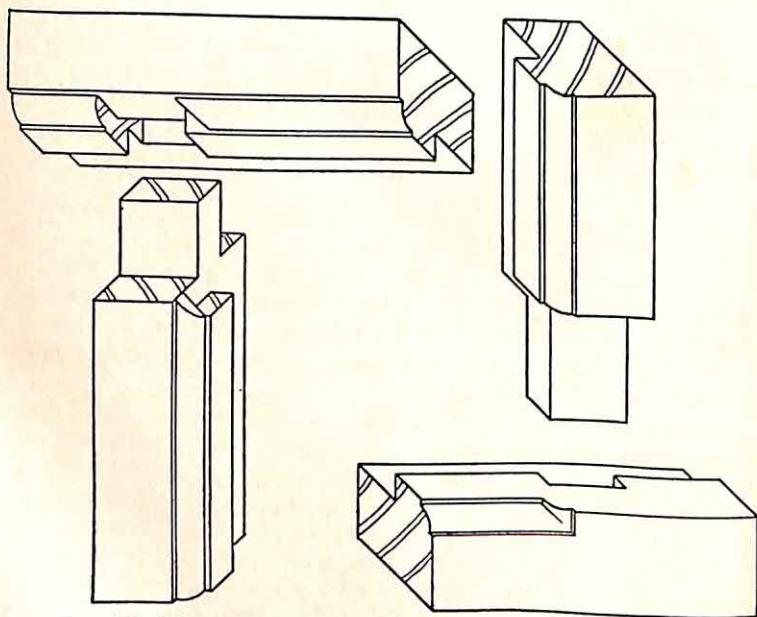


FIG. 85. METHODS OF FORMING JOINTS IN LARGE FRAMES

The same idea can be used to advantage where long and heavy cramps would otherwise be necessary, as in a frame for a very wide doorway. The tenon may be left long, as in the "transom to stile" joint (Fig. 86) so that a hole can be drilled through the tenon as shown; the steel pin is used to draw the joint tight, and the whole is secured by wedges. If necessary, a wood dowel pin may also be used through the joint, as at the head of the stile.

To preserve the right angles of linings and frames until fixed in the final positions, especially when of light construction, they should be lightly braced and stayed as shown in Fig 89.

INTERSECTIONS OF MOULDINGS. There are three methods available for forming intersections of mouldings—

(1) *Mason's Mitre* (Fig. 85). On the continuous (mortised) member the moulding is stopped a short distance from the mortise, but run right through on the tenoned member. After the joint is fixed, the mitre is formed in the solid material with chisel and gouge.

(2) *Mitred* (Fig. 85). A square seating to receive the shoulder of the tenon is made at the level of the deepest part of the moulding on the mortised member. The two ends of the moulding are mitred and accurately fitted as shown; sometimes the mitre is carried right through the width of the stop.

(3) *Scribed*. When made by machinery the whole profile of the member is formed on the shoulders of the tenons, and this simply fits right over the moulding and stop of the mortised piece. This method would be too laborious for handwork, so a square seating is formed on the mortised member, but leaving a short portion of the moulding, over which fits a short scribing on the tenoned piece.

Scribing is considered the best of these methods, as shrinkage of the tenoned part does not cause open joints at intersections of mouldings. Any undercut mouldings, however, must be mitred; e.g. a bead moulding (Fig. 86).

Planted door-stops (Fig. 87) may be either mitred or scribed.

An interesting if rather complicated joint occurs where door and fanlight open on opposite sides of a frame, particularly when both edges are moulded as in Fig. 86. Sloping shoulders must be formed; these will slope opposite ways on the two faces of the frame.

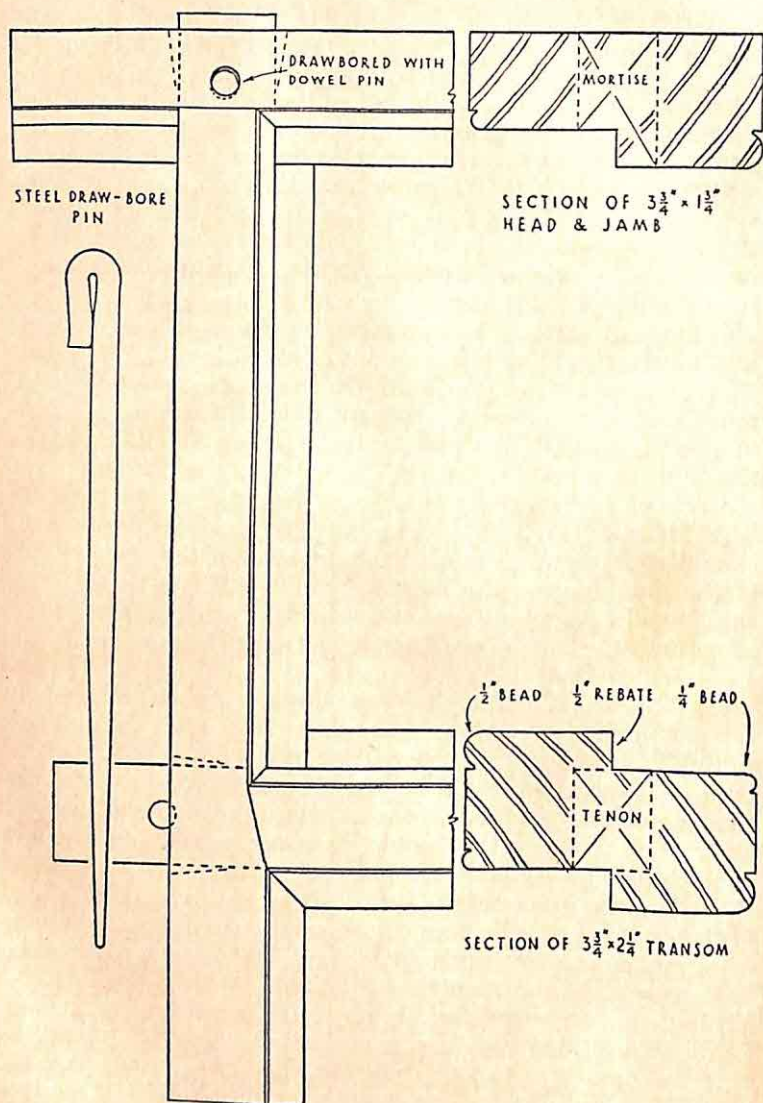


FIG. 86. DOOR AND FANLIGHT FRAME JOINTS

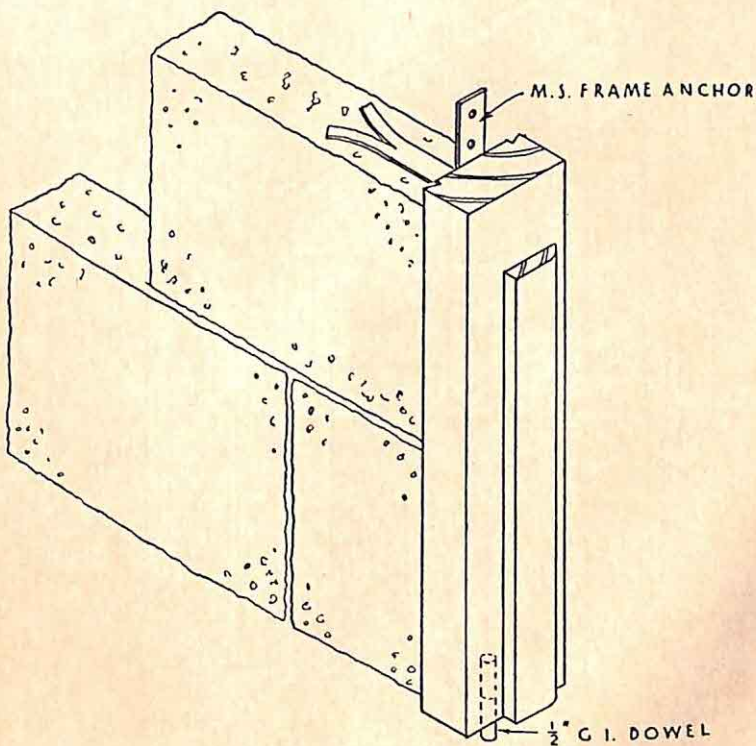
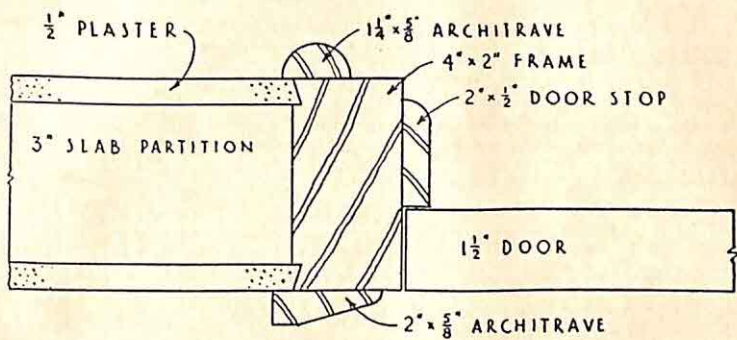


FIG. 87. INTERNAL DOOR FRAME

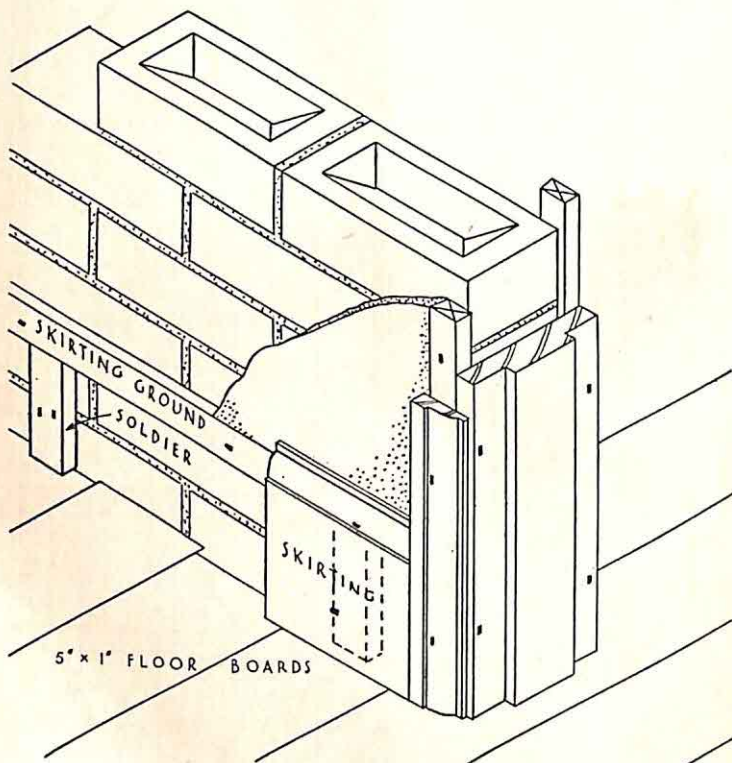
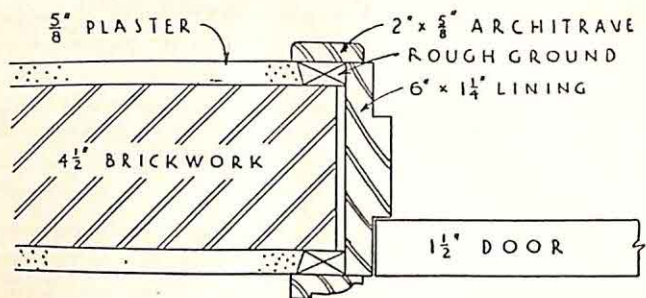


FIG. 88. INTERNAL DOOR LINING

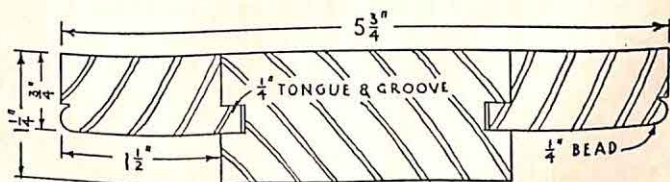
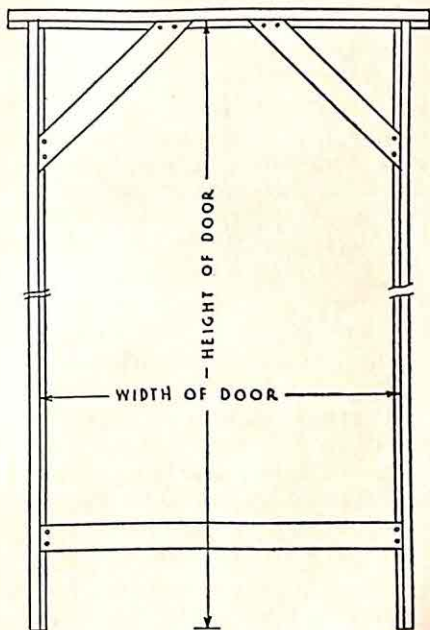
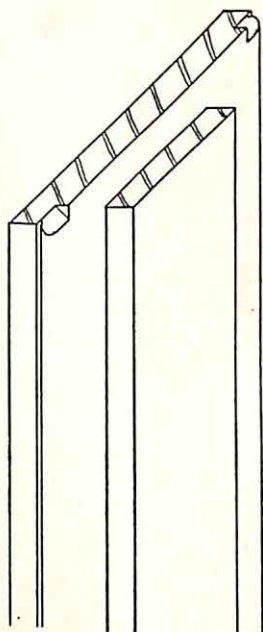
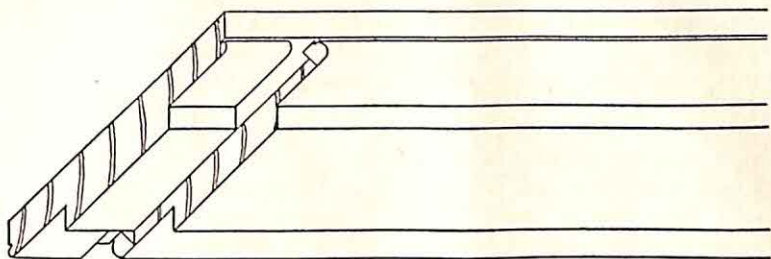


FIG. 89. JOINTS IN DOOR LININGS

Internal frames may have a transom and no head (see Fig. 84). These are intended for fixing between floors as a guide for the bricklayer while building slab partitions. The portion over the door may be similarly filled, or left hollow and subsequently covered with lath and plaster or a piece of plasterboard.

Kitchen Door and Windows (Fig. 90). *Frame.* The sections of members and construction are much the same as for the casement frame shown in Fig. 91. In this case the sashes open outwards and the door opens inwards. There are two possible alternatives in the arrangement—

(a) to stick rebate and moulding on opposite edges on the same member (door jambs); this may prove difficult to do particularly by hand, and in any case considerable wastage results; (b) to use rectangular section material, and fix the stops separately (planted stops) as in a previous example. By using this method the joints are simplified.

The over-all height of the frame is 8 ft 6 in. and this would often be the floor-to-ceiling size. The door is 6 ft 4 in. $\times$ 2 ft 4 in., so that these sizes fix the horizontal lines and two of the vertical ones, those on either side of the door. Bearing in mind the desirability of keeping glass sizes as far as possible the same, the other jamb is set an equal distance away (or as near as well-arranged brickwork will allow).

Door and Sashes. The normal distance from floor to door handle is 3 ft to 3 ft 3 in., and this corresponds to the mid point on the middle rail. Much the same sections are used with the lower part as for the panelled door, but with tongued and grooved boards for the panel. As maximum light is required the members in the upper glazed part are reduced in size which results in a diminished or gunstock stile; this requires a joint of the type shown in Fig. 18.

By using 3 in. top and bottom rails in the sash, glass sizes are kept the same height, and the general design benefits from the continuous horizontal lines. The two fanlights are the same size, glass sizes being therefore identical. As the frame is arranged, all glass heights are the same, the only discrepancy being in the widths of the panes in the door; this is unavoidable.

Doors on exterior walls opening inwards often allow the penetration of driving rain between sill and bottom rail.

By using a sill which is well weathered on the outside, rain is quickly drained outwards; and by letting a water bar into the sill as shown, wind is prevented from driving water inwards. The bar must not stand too far above sill level or people using the door will be liable to trip over it.

Hinges in the example are shown in line with the sight lines (daylight opening) of the sashes. This is not in any way a rule, but looks neat.

CASEMENT FRAME JOINTS. The section of the frame is designed to provide a housing for the sash $\frac{1}{2}$ in. deep; to facilitate jointing, the moulding is usually made the same depth. The head and jambs have a common section, the mullion is moulded and rebated on both sides, the sill is wider and has a weathering slope, and the transom is a sort of combined head and sill (see Fig. 90).

With machine-made joints a reverse of the moulding is worked on the end grain of the shoulders, but this would prove too laborious for handworking. The square part is therefore removed to the line of the rebate and moulding, leaving a little portion of the moulding which is either mitred to fit a mitre worked on the shoulder or scribed like a sash joint.

Mortise and tenon joints are different from the usual kind, being less than one-third the thickness of the material. Once the frame is fixed it is not subject to lateral stress or twisting; the joints will be quite adequate if they are strong enough to keep the members positioned before fixing, therefore heavy work punching very wide mortises is avoided.

The inner edges of the frame are known as the sight lines and when setting out from the rod both these and the rebate lines are marked on, this precaution often obviating errors in the work.

Mortises are usually taken through the full width of the material and it is advisable with big frames to leave plenty of length on the tenons so as to do without very long cramps. Draw-bore pins are used instead. These consist of tapered steel pins about $\frac{3}{8}$ in. thick, which are driven into holes bored in the tenons in such a way that the joint is driven home by the wedging action of the pin. The joint is maintained by a wooden pin which is driven in to replace the draw-bore pin.

A frame which is to be used externally must be assembled

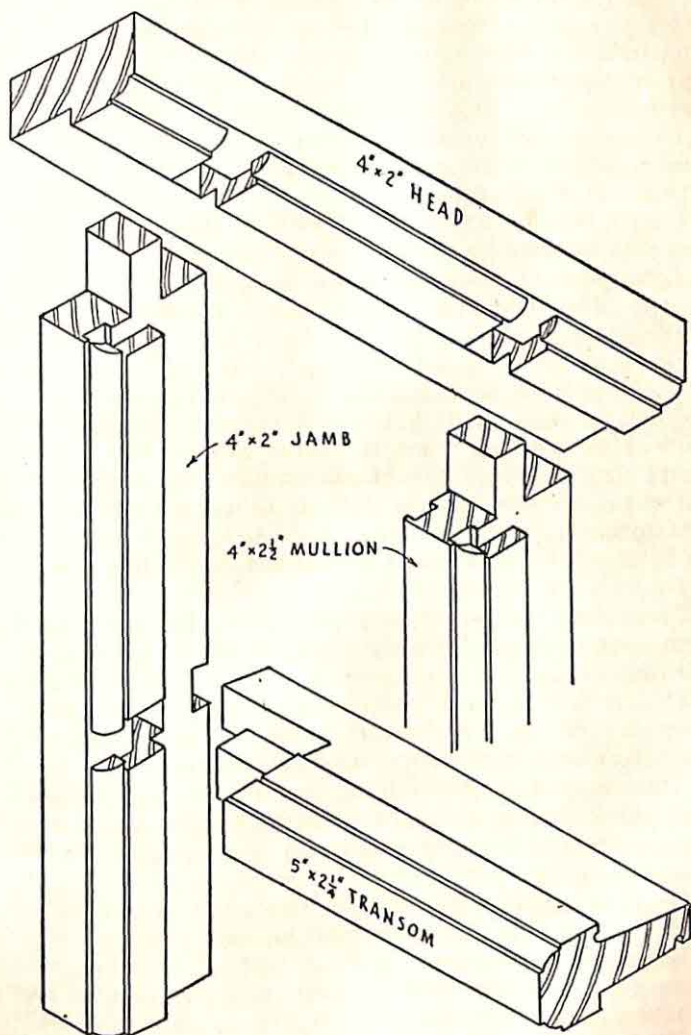


FIG. 91. JOINTS IN CASEMENT FRAME

with lead paint, not glue, to prevent penetration of moisture into the joints which would cause rot. As the material is comparatively thin, moreover, wedges should be supplemented by dowel pins which pass right through the joints. Notice that as the transom is wider than the joints, it must stand forward. It is sound construction to house it $\frac{1}{4}$ in. into the face of the jamb. Shoulders at the bottom of the jambs will have to slope to fit the sill.

The mullion has to be in two parts, and the tenons passing into the transom must be stumped; that is, cut to meet half-way or a little short so that the joint is certain of being tight on the outside.

SKYLIGHTS

Where it is necessary to obtain light through a sloping roof, an opening is formed in the rafters and heavier trimming timbers are used in much the same way as in upper floors (Fig. 92).

Two main considerations influence the design of a skylight—

- (1) exclusion of the weather,
- (2) disposal of condensed moisture from the inside.

The first point is largely the concern of the plumber, who has to dress sheet lead around the lining and the main roof slope in such a way that, when the tiles or slates are fixed, no water can penetrate.

The problem of condensed moisture inside is also important. Warm air can hold a greater amount of water vapour than cold air. Therefore when warm air rises to the glass surface and becomes chilled, drops of water are formed which run down and, unless drained away, drip off into the room below.

Two methods are available; the best method consists in making a triangular recess, $\frac{1}{4}$ in. deep, in the bottom rail under each sheet of glass. The base of the triangle collects the moisture and the narrow opening at the outer edge is sufficient to drain the moisture away but too small to allow an undesirable amount of cold air to enter. In many cases, however, the narrow opening gets filled with dirt and ceases to function.

The second method is easier. The bottom rail is made $\frac{3}{16}$ in. thinner, thus saving the work of recessing. It will be appreciated that cold air has a larger opening through which it can

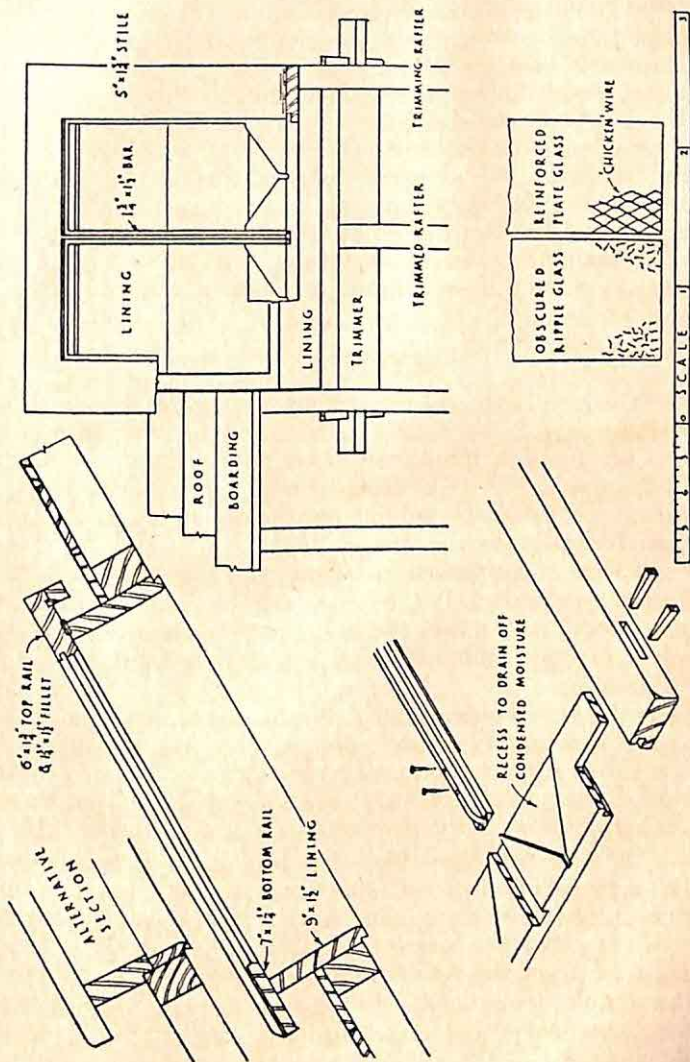


FIG. 92. SKYLIGHT FRAME AND LININGS

pass, and that the glass receives no support from the bottom rail. For these reasons, the method is not so frequently used for exposed positions.

Linings. The linings are formed into a four-sided frame (see Fig. 92), dovetailed or tongued and grooved at the corners. The frame is placed within the trimmed opening, wedged in position and fixed with screws. It serves to cover the rough timbers of the roof, and to raise the sash off the roof slope. If desired it can be in two parts, and in either case the lower edge is rebated to form a key for plaster.

Sash. This is of wider material than usual, but joints between top rail, stiles, and bars are made in the usual way (Fig. 97). The bottom rail, being thinner, has barefaced tenons where it joins the stiles and grooves to accommodate the bars, which must consequently be fixed with screws. A weather-fillet is tongued and grooved to the underside at the top edge to exclude driving rain; if desired this fillet can be fitted all round.

Butt hinges are provided at the top edge if the sash is to open and a winding gear of the rack-and-pinion type employed to raise the lower end.

Glass. Stronger material than for ordinary windows will be necessary. Plate glass at least $\frac{3}{16}$ in. thick is advisable, and it is desirable to use an obscured variety, so that sooty streaks are not made too obvious in a place where cleaning is likely to be difficult. If the glass is accidentally broken, it may injure people below; for this reason glass with wire reinforcement is often employed, the wire holding the pieces in position until taken out by the glazier.

THE KITCHEN DRESSER

A kitchen dresser or its equivalent (Fig. 93) is a good example of a necessary joinery fitting. The dresser is made in two main parts, the pedestal or lower portion, and the glass-panelled upper cupboard.

Taking the upper portion first the two sides 9 in. by 1 in., finishing at $8\frac{3}{4}$ in. by $\frac{7}{8}$ in. are grooved to receive the shelves and fixing is done with glue and oval brads or screws. The front frame is mortise and tenon jointed and fixed to the carcass with screws. The plywood top is not required if the dresser is to reach the ceiling, and the moulding used as

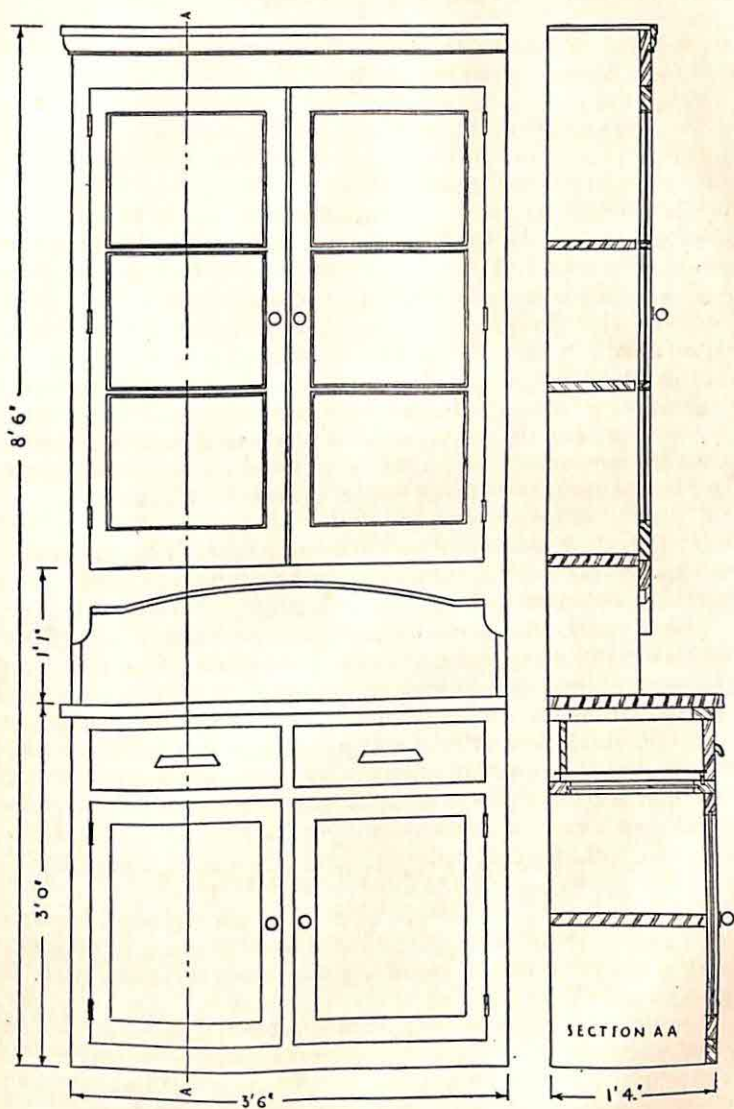


FIG. 93. KITCHEN DRESSER

a cover for the joint. Otherwise, of course, plywood top and moulding may be fixed in the shop.

When the carcass is complete, the doors are hung, each on a pair and a half of 2 in. butts (preferably brass). Glazing fillets $\frac{1}{2}$ in. by $\frac{1}{4}$ in. are mitred into the rebates to retain the glass, and fixed with panel pins.

The pedestal is made somewhat similarly. In the example shown, one end is against a return wall and therefore one side could be saved by supporting the end of the shelf on a bearer fixed to the wall. The rails above and below the drawers are edgewise on elevation, the lower one being the front member of a horizontal frame immediately under the drawers and having plywood panels, known as dust boards, to prevent dust making its way into the cupboard below. The dustboard framing is also the surface on which the drawers run; for wearing purposes it ought to be of hardwood, oak or beech. Drawer guides are screwed to the dustboard framing.

Upper and lower portions will both be fixed to the back wall, but they may also be joined together. Two grooves in the flat table will accommodate the standards of the top portion, and a few screws through the underside of the top rails will fix the flat table top.

Drawer design has been discussed elsewhere; one new point should be noted here, however; the drawer stops consist of short lengths of hardwood glued upright into shallow mortises. A cheaper and less effective type of stop is a small piece of plywood glued and pinned on.

When setting out the rod for this piece of work, the full depth need not be shown; use broken lines, and figure in correct depth dimensions.

SECTION V

CARPENTRY: FIXINGS AND FINISHINGS

THIS section deals with the details of construction in carpenters' work, and the order of procedure in carrying out work on the site. It includes the simpler structural work of floors, roofs, formwork and centers; the geometry of roofing; the fixing of joiners' work on the site, and all wood finishings.

ORDER OF PROCEDURE ON THE SITE

Floors. When the brickwork reaches damp-course level, the carpenter will usually lay the wall plates and ground floor joists. In very damp conditions this operation may be delayed until the roof is on. In the majority of domestic buildings, however, the first floor joists are built into the brickwork; so they must needs go in as the work proceeds.

Door and Window Frames. There is a choice of procedure where door and window frames are concerned. They may be stood in position with temporary braces to hold them while the bricklayer does his work, or the brickwork may be put up and the frames put in afterwards. In the former case, frame anchors are screwed to the frame and the fishtailed ends built into the brick joints. In the latter, wooden plugs are driven into spaces between bricks, to provide a hold for screws, and folding wedges driven into gaps between frame and brickwork at top and bottom. Internal door frames are usually left until the outer shell and joists are finished and set up as a guide for the partition walls. If the partition walls are built independently, a thinner door frame known as a lining is used. But this is to anticipate.

Roof. The wall plates for the roof are fixed as soon as possible and the work of putting on the roof pushed forward. This task finished, the various trades can work inside under cover. The first job is to lay the floorboards.

First Fixings may now be put in (Fig. 94). These serve two purposes—

- (a) a guide for the plasterer,
- (b) a groundwork to which the second fixings (skirting, picture rail, linings, etc.) will later be attached.

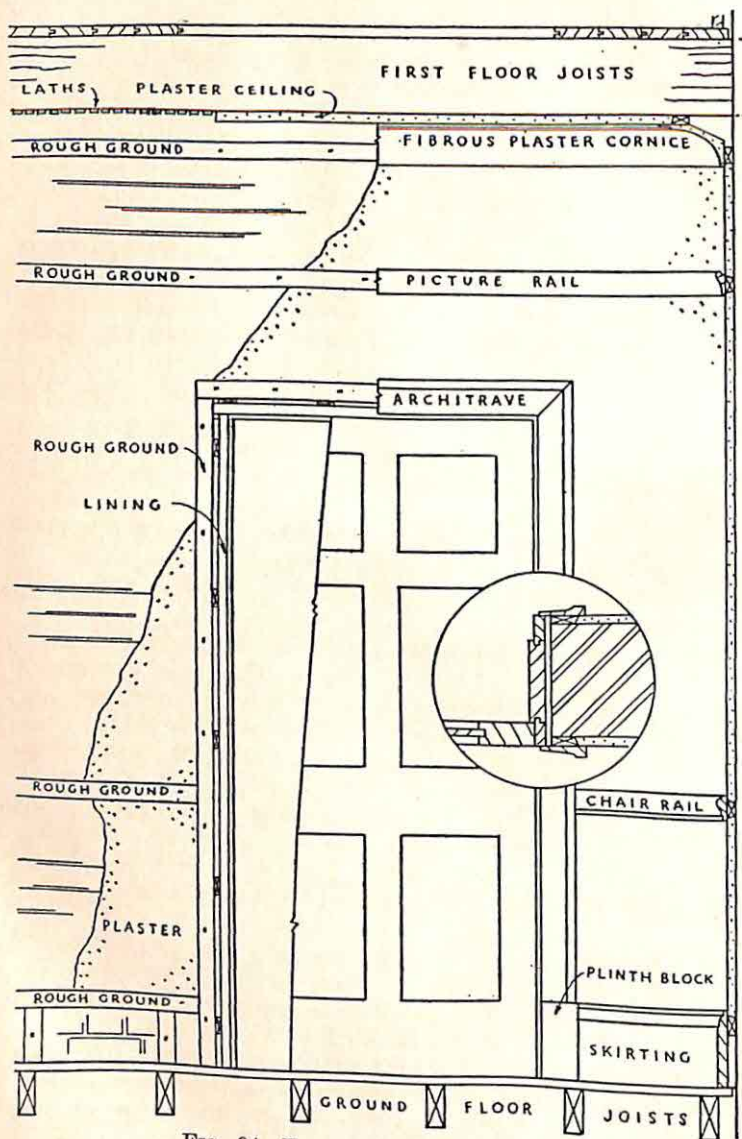


FIG. 94. FIRST AND SECOND FIXINGS

These first fixings are usually of unwrought timber, having an inward bevelled edge adjoining the plaster. To obtain a hold for the rails, breeze blocks may be built into the brickwork; or a plugging chisel may be used to remove a portion of mortar joint at intervals into which wooden plugs are driven; or nails may be driven directly into mortar joints. While fixing, the carpenter's task is to keep the grounds straight on the face; as the brickwork has slight dips and bumps, he may have to chip portions off the back or put thin slivers of wood behind as packing pieces.

Plastering. This first fixing completed, the plasterer can begin operations. Laths are fixed on the underside of the first floor joists to enable the ceiling plaster to be put up (unless, of course, plasterboard ceiling is used, when it is nailed to the joists directly).

The wall joints will have been raked out to obtain a key for the plaster, and this is put on in two or three coats. With two-coat work the first may be worked very slightly behind the level of the grounds, a straight-edge being traversed across the grounds. This coat is scratched, and when it is dry the final coat is put on, finishing slightly in front of the grounds.

Second Fixings. When the plaster is thoroughly dried out, the next operation is to fix the stairs, cupboards, dresser and any other built-in fitments. It may be noted here, however, that stairs are sometimes fixed before the plastering is done. This may be very convenient but is not an ideal arrangement, for woodwork becomes damp with the moisture which evaporates from the plaster; it is also liable to be damaged by the traffic of plasterers and their labourers going up and down. Where stairs are fixed before plastering they should be adequately protected by thin wood coverings, at least on the treads.

If door linings are to be used, these are fixed to the grounds with an occasional fixing to plugs in the brickwork. The plugs may be sawn off to the level of the grounds, or packing pieces used to make a firm backing on which to fix.

Finishings. The architraves are now mitred around door openings (Fig. 94). They serve to cover joints between plasterwork and woodwork to the opening, and provide a pleasing frame for it.

Skirtings have to be fitted tightly to the floorings. To do this, the length of skirting is put into position against the wall with the top edge level and with small blocks holding it slightly off the floor. Dividers are set to the distance which is required to mark the correct amount to be removed from the bottom of the skirting; a line is scribed on it with one leg while the other is run along the line of the floor giving a line on the skirting which is parallel to the floor, with its irregularities. When this waste is removed, the skirting will fit the floor exactly. To ensure a good tight joint on the front, the carpenter saws the edge slightly undercut. The skirting is fixed with nails to the horizontal ground and to the short vertical grounds called "soldiers."

Dado and picture rails are then fixed and are followed by the last of the second fixing operations which is to hang the doors in the openings.

FLOORS

Ground Floor (Fig. 95). Ground floors in timber must be designed with the object of keeping the wood healthy. This necessitates the exclusion of damp and an adequate circulation of air; for under damp stagnant conditions dry rot, timber's greatest enemy, flourishes. The layer of concrete called variously surface, site or oversite concrete is intended to prevent unhealthy vapours rising from the soil and to do away with any possibility of fungus growing. Although the ground is thus sealed off, moisture may still make its way through the surface concrete on a damp site by capillary action through the tiny pores of the material; therefore no timber is put in below the damp proof course in either outside walls or sleeper walls.

To ensure that air is free to circulate around all timbers, air vents must be formed in outside walls and the intermediate supporting walls must be built honey-combed. Particular attention should be paid to bay windows and other isolated parts of the construction, to make quite certain that no part is left where air may stagnate; dry rot has been known to destroy neglected corners of a floor whilst the rest remained sound.

What a fuss, you may be thinking, about a part of the construction that no one sees! Well, dry rot in ground floors is a great menace, and its ravages cost large sums of

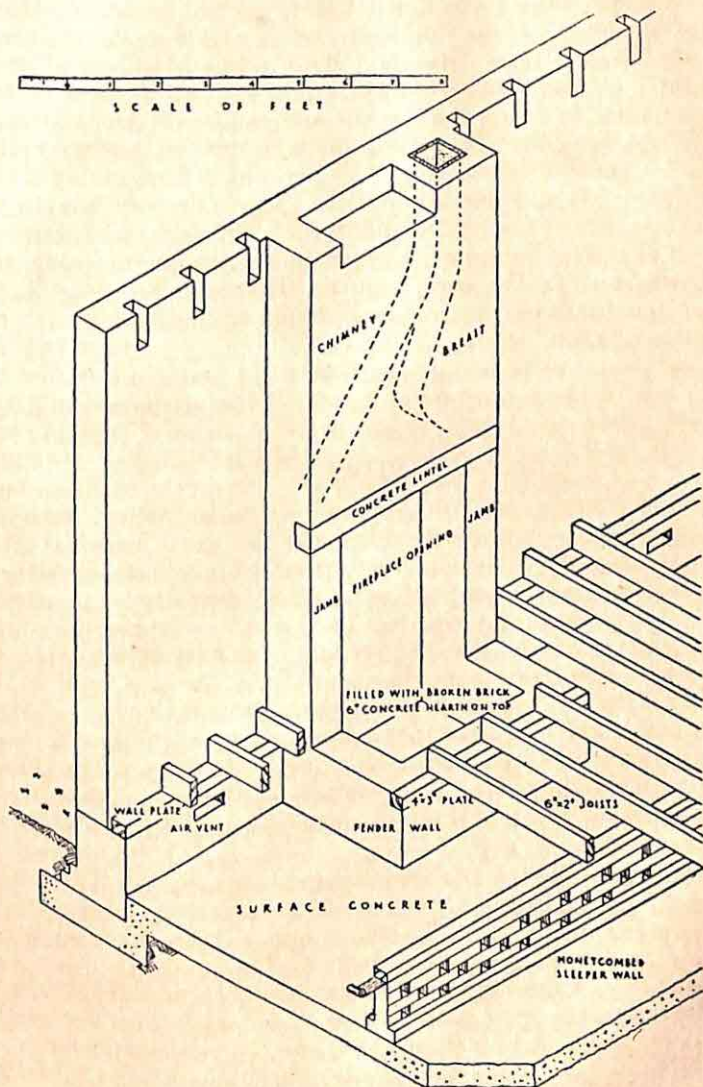


FIG. 95. GROUND FLOOR JOISTS AND FIREPLACE

money every year, besides necessitating the most objectionable job of tearing up floors and skirting and trying to eradicate the disease by burning walls and surrounding woodwork with blowlamps. Even then, one is never quite certain of the effectiveness of the remedies. How much easier to do all that is necessary when first building!

Fireplaces (Figs. 86 and 87). Building by-laws control the use of timber around fireplaces. Naturally any woodwork must stop within a safe distance of a fireplace, and 18 in. in front of the jambs and 6 in. either side of the opening are usual allowances. For this purpose, on the ground floor a fender wall in $4\frac{1}{2}$ in. or 9 in. brickwork is built round the hearth (to support the hearth slab and the adjoining joists). It rests on the surface concrete and is filled with incombustible material; this may be broken brick or stone consolidated by tamping, and often known as hardcore. On this the concrete (occasionally stone) hearth is laid, its outer margin resting on the fender wall. The joists rest on the wall and butt against the hearth without any framing or jointing of any kind. To make a neat finish for the boards, a marginal strip of the same thickness may be mitred around the hearth, or a thicker hardwood curb may be fixed. The latter saves the householder the additional trouble and expense of obtaining the usual wood, metal, or tiled curb.

Tiles are laid in Portland cement and sand to bring the front part of the hearth up to the same level as the flooring, while the back hearth, that part immediately under the fire, is made up with Portland cement and sand.

The fire will cause a constant stream of air to make its way up the chimney and consequently more air must enter the room to replace it. Any gaps in the flooring will allow air to be drawn through which may cause an unpleasant draught around the feet of people sitting by the fire. For this reason tongued and grooved boards should be used in preference to the ordinary square-edged kind, as the latter shrink and leave open joints.

Upper Floors (Fig. 96). In an upper floor the joists have to span a greater distance than on the ground floor, where sleeper walls provide intermediate support. The joists must therefore be much stronger. Whereas 4 in. $\times$ 2 in. joists may at times be used for ground floors, it is not often that joists less than

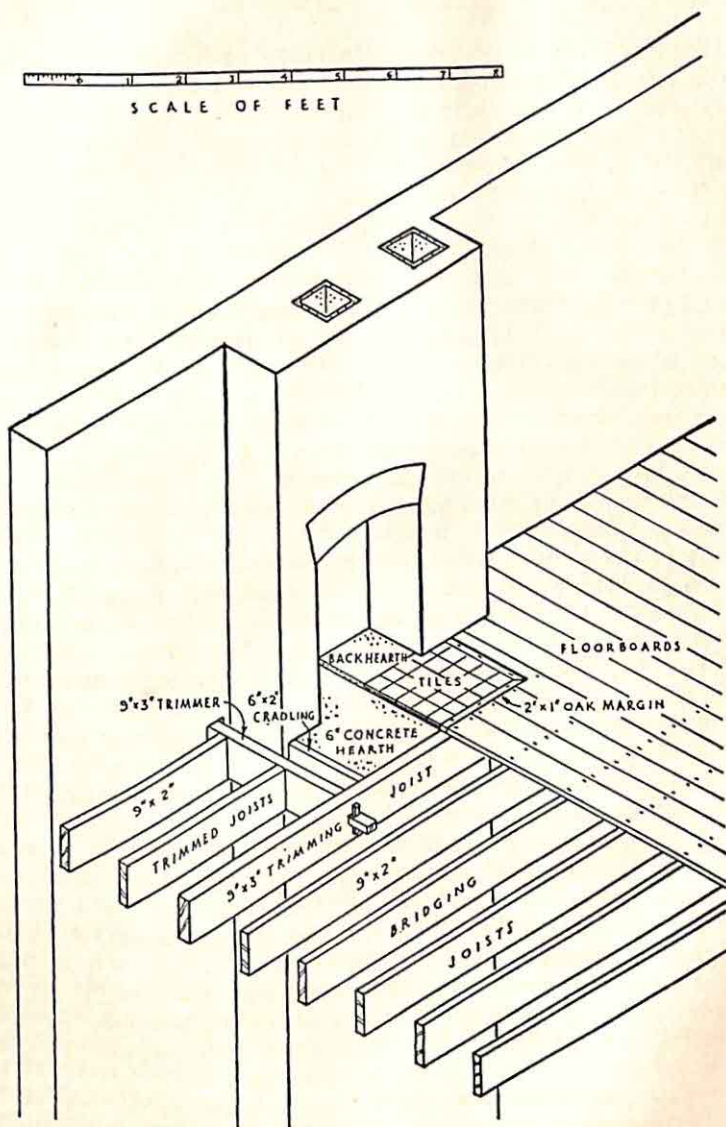


FIG. 96. UPPER FLOOR JOISTS AND FIREPLACE

7 in. $\times$ 2 in. are used upstairs; and 9 in. $\times$ 2 in. is the common size. A rough guide is given by the formula—

$$\text{Depth for 2 in. joists} = \left(\frac{\text{Span in feet}}{2} + 2 \text{ in.} \right)$$

Thus 12 ft span gives $1\frac{1}{2} + 2 = 8$ in. In this case 8 in. $\times$ 2 in. joists will be suitable.

Method of Support (Fig. 97). The ends of the joists should rest on a continuous plate of some kind, to distribute the load evenly on the wall and in case a faulty brick has been used accidentally under a joist. The plate may be of wood; this is quite suitable provided air can circulate around it, but to bed timber on wet mortar in a wall may be the start of trouble from dry rot. A better idea is to use a 4 in. $\times$ $\frac{3}{8}$ in. galvanised iron plate if the plate is to be built in. Two other methods of supporting timber plates on walls of uniform thickness are (a) to have continuous courses of brickwork corbelled out, or (b) to use iron brackets. The latter method is not particularly sound, as a great deal of weight is thrown on one brick; and both have the disadvantage that an unsightly projection is made in the room below. A plaster cornice may, however, be used to conceal this.

Openings. Any opening in an upper floor which necessitates cutting the joists must have a strong framework around it to support the shortened ends. This framing is known as the trimming, and the timbers used are the trimming timbers, usually thicker than the ordinary joists. That which carries the ends of the joists is the trimmer; the joist carrying the ends of a trimmer is a trimming joist; ordinary joists are bridging joists; and shortened ones are trimmed bridging joists. Openings commonly provided are those for stairs and around fireplaces.

Upper Floor Fireplaces (Figs. 96 and 97). As with ground floors, the joists must stop within 18 in. of the face of the jambs and 6 in. on either side of the opening. As there is no fender wall to support the ends of the shortened joists, a heavier timber is used to carry them and the trimmer is in turn supported by trimming joists, also of heavy section. Joists may run parallel or at right angles to the wall; consequently two methods of trimming are used (see Fig. 98).

By-laws do not allow timber to be built into brickwork

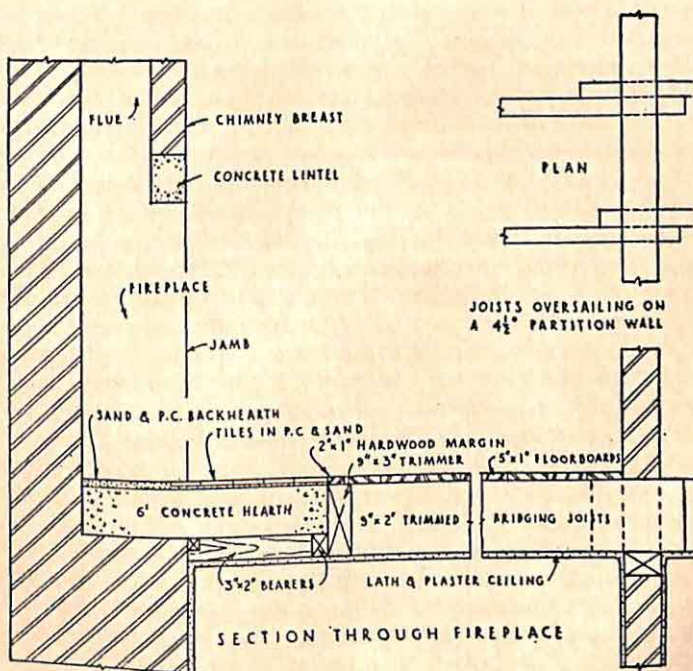
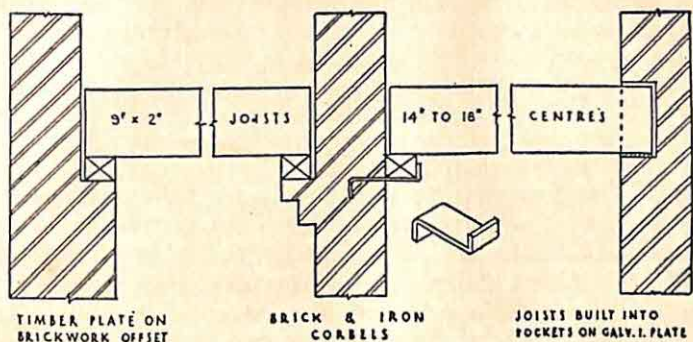


FIG. 97. UPPER FLOOR: SUPPORT OF JOISTS AND SECTION THROUGH FIREPLACE

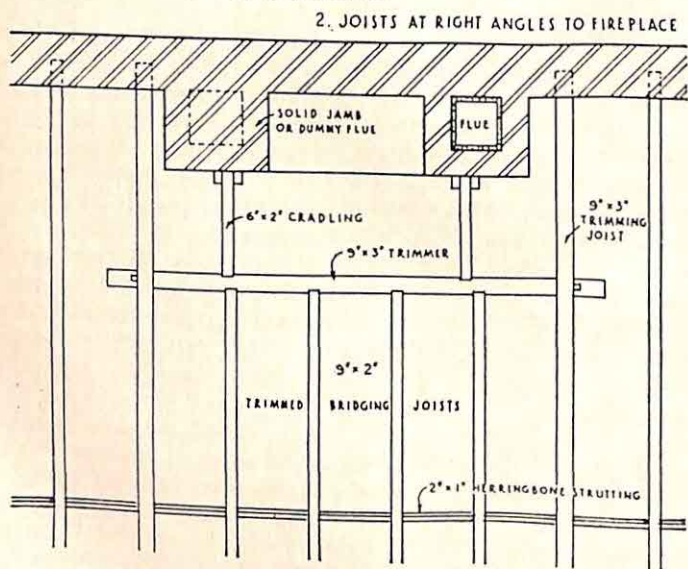
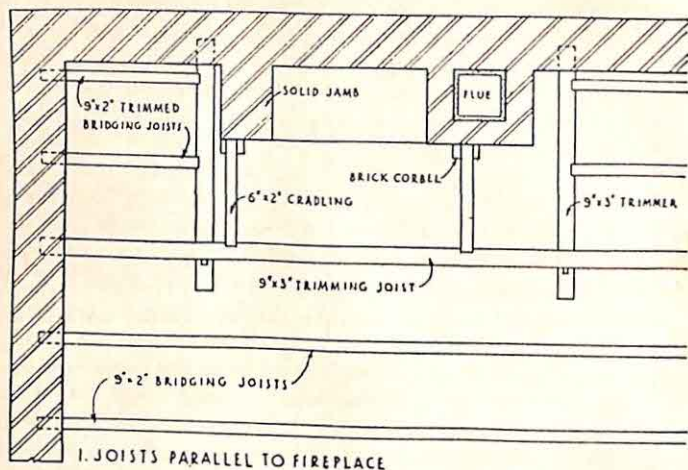


FIG. 98. UPPER FLOOR TRIMMING AND FIREPLACES

nearer than 9 in. to the inside of the flue because of the risk of fire; this will account for several points in the construction, including the method of supporting the cradling pieces, resting on corbels (Fig. 98). Cradling pieces are used to contain the concrete hearth when it is laid and to provide fixing for floor finishes around the fireplace.

Much of the concrete hearth rests on the brickwork of the chimney breast from the floor below; but the tendency for the slab to tip downwards under its own weight is counteracted by a bearer, which supports its outer edge and which is securely fixed to the trimming or trimmer joist.

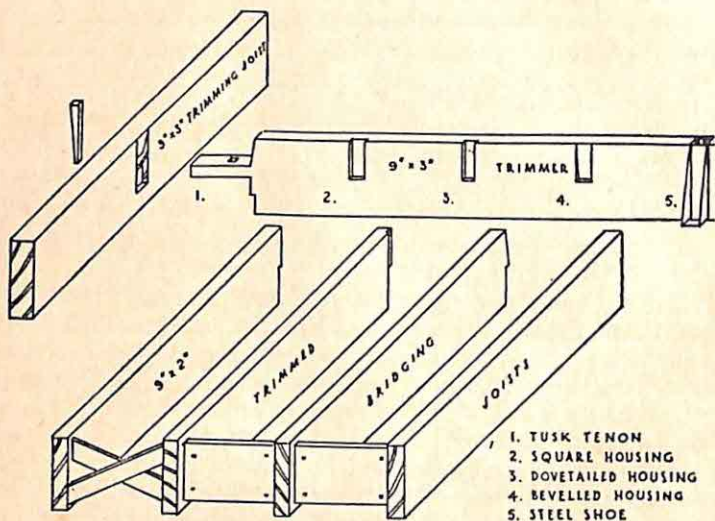
To enable the concrete hearth to be laid, a temporary platform of rough timber is usually built underneath, known as shuttering. Other methods of supporting the hearth consist of a trimmer arch (now largely in disuse) or an iron plate shaped like a trimmer arch, which serves the same purpose as wooden shuttering. Unlike the latter, which is removed when the concrete is set, the iron plate is left in.

The hearth is not as thick as the floor, so will need some bearers on the underside to give a flat ceiling finish.

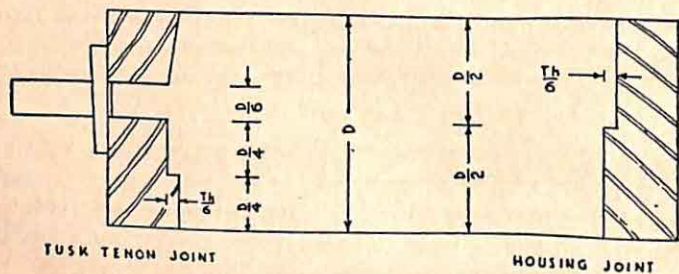
Strutting (Figs. 98 and 99). Upper floors to dwelling-houses may have clear spans up to 16 ft without using heavier timbers than common joists 2 in. thick. Even this length of timber will be rather inclined to give. The joists should, if possible, span the shorter way of an upper room; and as a further help in keeping the timbers as stiff as possible, strutting is put between the joists. This may be of two kinds, solid or herringbone. The former consists of solid distance pieces simply nailed in place. When the joists shrink, solid struts become loose. Herringbone strutting is therefore preferable; it consists of double lines of diagonal braces spaced not more than 6 ft apart.

TYPES OF FLOORING (Fig. 100). Tongued and grooved boarding is best for general use; but as the joint uses part of the width, square-edged material covers a greater area. It is consequently cheaper and in some districts is the most frequently encountered. Ploughed and tongued boards use the full width and still have a tongue to seal the gaps which develop between wide boards due to shrinkage.

Rebated boards with a fillet may be used for a factory floor having no ceiling, to prevent dust finding its way through to



HERRINGBONE & SOLID STRUTTING



SOUND PROOFING

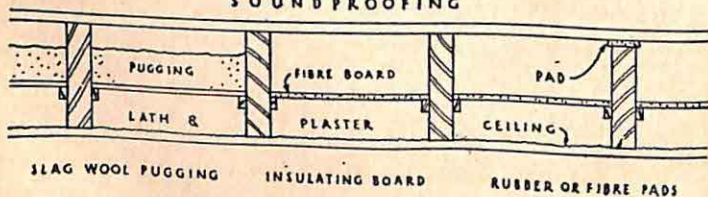
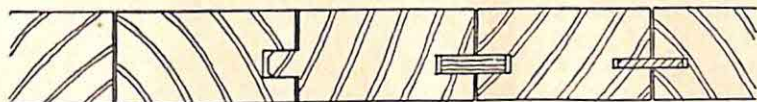


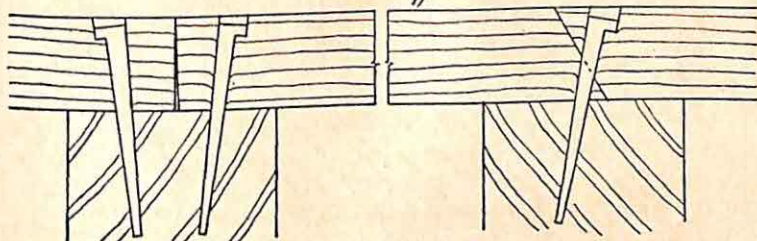
FIG. 99. JOINTING OF TRIMMERS, STRUTTING OR BRACING. SOUND PROOFING



SQUARE EDGED TONGUED & GROOVED PLOUGHED & TONGUED HOOP IRON TONGUE



REBATED FILLETED SECRET NAILED DOWELLED



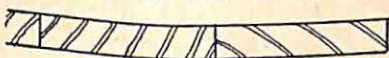
SQUARE HEADING JOINTS SPLAYED



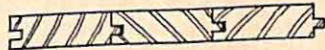
BAD FLOORBOARDS BADLY LAID (SHARP EDGES WEAR LINO' & CARPET)



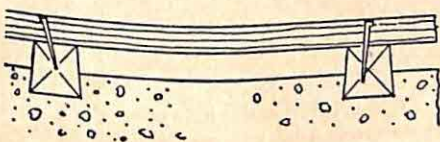
MAKING THE BEST OF A BAD JOB (HEARTSIDE UP)



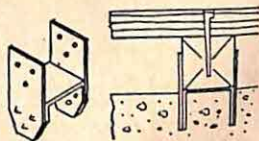
GOOD FLOORBOARDS



IDEAL - NARROW BATTEN T & G BOARDS



FILLETS BEDDED IN CONCRETE



FILLETS FIXED WITH CLIPS

FIG. 100. JOINTING AND FIXING FLOORING BOARDS

the rooms below. The rebated joint has no particular merit; but a complicated joint which is rebated, tongued and grooved is used for ballroom floors in order that nails used in the fixing will be hidden. This allows the surface to be highly finished to present an unbroken surface for the feet of the performers.

Dowelling is most often used for wood blocks, but can be used for boards. The dowels keep each block flush with its neighbour, an adhesive substance like pitch or bitumen being used to bed them on and attach them to the groundwork (usually concrete).

Wood grounds or fillets provide nail-hold for boards fixed on top of concrete floors. The fillets may be bedded in the concrete or secured to clips inserted in the concrete while it is wet.

Sound Insulation. The transmission of sound through walls and floors is a matter of the greatest importance particularly in these days of wireless, night-shift work, and flat-dwelling. Sound relies upon vibrations for its production and transmission. A mouth-organ, a drum and the wires in a piano are typical instances of a piece of material making vibrations. These set up vibrations in the air, which in turn set the ear drum vibrating. The usual upper floor of boards, joists and ceiling is very much like a drum with its two skins stretched taut across an intervening air space; it is consequently highly adapted to transmitting sounds, especially of the percussion or impact kind—a person jumping about is all too readily heard by those on the floor below. The more flimsy the structure, the more readily does it vibrate.

Have you noticed, however, that a furnished room is less noisy than an empty one? Sound may be said to be absorbed by some materials and either reproduced or reflected by others. Heavy curtains, carpets, and soft furnishings will not reflect sound. (There is, incidentally, a good reason for people singing in the bathroom; they are flattered by the volume of sound which is reflected from one hard surface to another. In a room of heavy furnishings, the same effort would produce comparatively puny results.)

Methods of Insulation. We may apply these ideas to building work. To discourage the passage of sound between rooms, thick walls must be used or a material of the blanket type incorporated; in the first case this entails the use of extra

bricks and in the second the insertion of felt or soft paper board in sheets, usually underneath the covering skin of wooden partitions.

In floors felt, insulating board or a layer of a woolly substance like sawdust or slag wool may be used. As sawdust makes rather a cosy nest for undesirable pests, slag wool is preferable; and since weight must not be put on the ceiling, fillets nailed on the sides of the joists must be used to support the insulating material (Fig. 99). Plaster ceilings are better insulators than ceilings of thin sheet materials like plywood, pressed fibre and asbestos cement.

Laying Flooring (Figs. 100 and 101). Good floorboards are cut so that the annual rings run across the thickness. In this way shrinkage is less serious, and no curling takes place. If wrongly-cut boards must be used, it is a matter of choice whether the edges or middles of the boards will cause most annoyance when they warp. The edges are most severe on floor coverings, but boards laid heartside up have a tendency to "shell," and this is bad if the floor is intended for polishing or scrubbing.

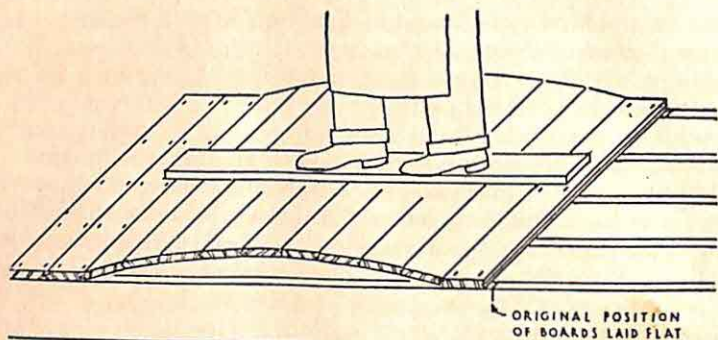
Some shrinkage is inevitable in floorboards; therefore when being laid they need cramping tightly. Use is made of heavy flooring cramps which can be clamped to a joist, while the screw part cramps the boards tight. Another type employs a long lever to obtain the necessary pressure.

As the carpenter often has to improvise a method of tightening with such materials as are to hand, three such devices are illustrated (see Fig. 101).

The first point to be borne in mind is that one or more boards must always be fixed first, or any pressure exerted will merely displace the joists. With these boards providing the resistance, any of the methods shown can then be used. Walls should not be used to obtain pressure, as the whole floor (or the wall itself) may be shifted.

All floor brads should be punched at least $\frac{1}{8}$ in. below the surface, not only in consideration of the plane used to level the joints (or the whole surface) flush, but also against the time when the boards wear thinner.

While superior floors in ballrooms, hospitals and other public buildings often have narrow boards secretly nailed (Fig. 100), quite often wood (or other) blocks are used. Blocks



"SPRINGING IN" FLOORBOARDS

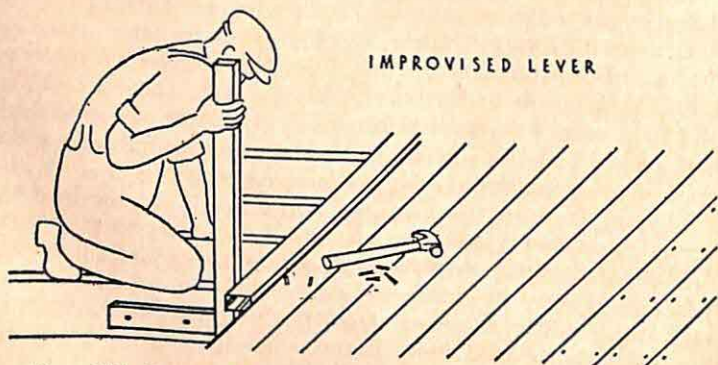
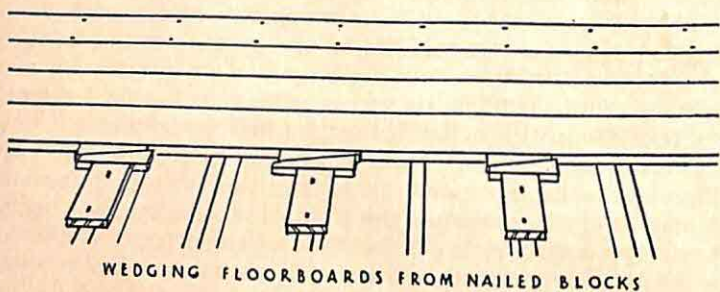


FIG. 101. LAYING FLOORING BOARDS: METHODS OF CLOSING JOINTS

are particularly suited to covering concrete; a mastic of the bitumen type is laid hot, and the blocks simply bedded in this. Each block is kept flush with its neighbour by a tongue and groove or dowels.

Common boarded floors can be improved by covering with thin slabs glued down. Being hardwood, the slabs need only be $\frac{1}{4}$ in. thick, and decorative patterns in contrasting woods are possible. This type of finish is known as parquet flooring. Parquet and block floors were at one time laboriously finished by hand planing and scraping; nowadays a great saving in labour is effected by the use of portable sanding machines.

HELP FOR OTHER CRAFTSMEN

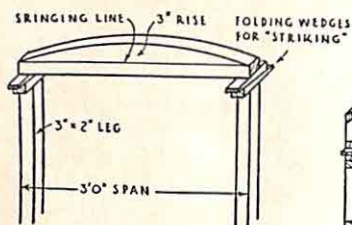
The carpenter is often called upon to help in the work of other craftsmen. Upon his skilled co-operation and accuracy will depend the ease with which his colleagues on the building can perform their several functions. This knowledge is a source of pleasure to most carpenters; but occasionally another feeling—that of being pestered and annoyed while trying to do their own work—may gain the upper hand. It is easy to see which state of mind contributes most to personal and general enjoyment of the work on a building, and which gets the job done most effectively.

While helping the other trades, the carpenter is in a position to gain valuable knowledge of the whole process of building and find added interest in his own work.

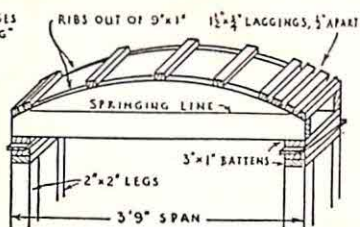
Centers for Brick Arches. Brick arches may be a prominent feature of the exterior of a building, but many such buildings are spoiled by the arches having a poor line. The first reaction of the person with a critical eye is to blame the bricklayer for lack of proper care and skill; but considering his dependence upon the carpenter this is not always justified.

Centers are usually of rough timber; the forming of the curve, however, needs to be carefully and accurately done. Where solid centers are concerned that is the end of it; but built-up centers with laggings across the ribs will need additional care to ensure that the laggings are of uniform thickness, and a final check must be made of the outer curve when all is complete.

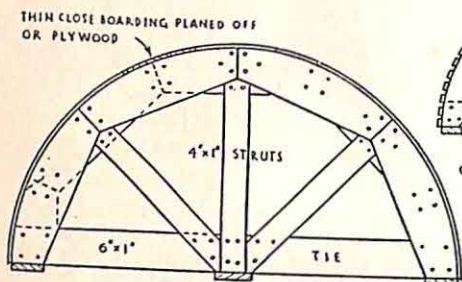
When making ribs (Fig. 102) select a flat surface on which a pencil setting-out curve can be marked and to which the pieces



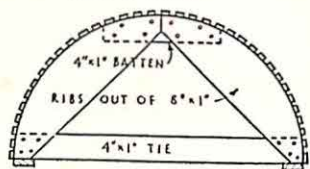
SOLID TURNING PIECE OUT OF 5" x 3" FOR SEGMENTAL ARCH 4½" THICK



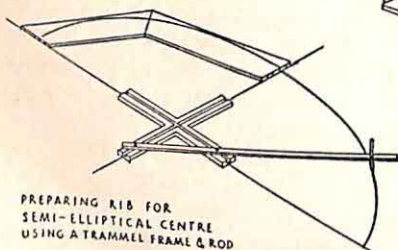
BUILT-UP CENTRE FOR SEGMENTAL ARCH 9" THICK



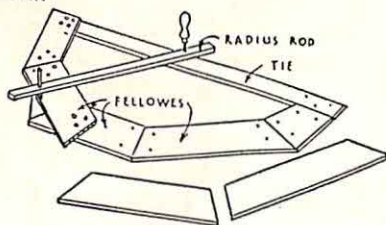
SEMICIRCULAR CENTRE SUITABLE FOR LARGE SPAN
FAIR OUTER CURVE FOR RUBBED & GAUGED WORK



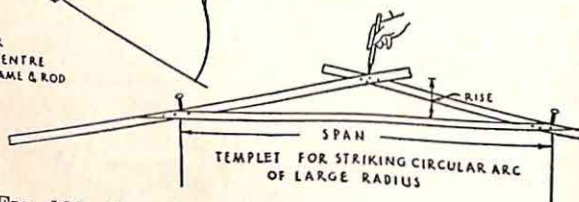
CENTRE FOR SMALL SEMICIRCULAR ARCH



PREPARING RIB FOR
SEMI-ELLIPTICAL CENTRE
USING A TRAMMEL FRAME & ROD



BUILDING UP A SEMICIRCULAR RIB



TEMPLT FOR STRIKING CIRCULAR ARC
OF LARGE RADIUS

FIG. 102. CENTERS FOR BRICK ARCHES

can be bradded temporarily. The rib is built up, the curve and springing line are marked on the face (making the necessary allowance on the radius for the thickness of the laggings) and the curve sawn and planed when the rib is securely fixed.

Arches are of three types; (1) *rough*, (ii) *axed* and (iii) *gauged*. Rough arches are built of bricks left rectangular; axed arches of bricks shaped with hammer, boaster and scutch; gauged arches of bricks nicely shaped by sawing and rubbing. The first two may only require openly spaced laggings of rectangular section. Gauged work, on the other hand, requires a fair outer surface obtained by bending thin boarding around the shape and planing to the finished line; or, alternatively, plywood cut across the sheet for ease of bending.

Truly elliptical arches are rare, for each brick has to be a different shape, making the work rather expensive. More usually three or five centers are used to strike a close approximation. Then only two or three patterns are needed. In either case the carpenter may have to prepare these patterns or templets to the brick-cutter's requirements.

Concrete Formwork and Shuttering (Fig. 103). There are two ways of casting concrete to the required shape—

(a) By depositing the wet concrete in the situation to be occupied in the building, making use of adjacent work to contain it while it is setting. This is known as *in situ* concrete.

(b) By casting a unit or member in a suitably shaped mould in any convenient position, allowing to set, dismantling the mould and subsequently placing the prefabricated unit in the required position. This is known as *precast* work.

In the first category foundation concrete, site concrete and floors are usually quite simple, as the concrete will be laid in a trench or between containing walls. Occasionally the carpenter has to place a barrier (screed or shutter) where, for some reason, only a portion of the work is to be done at a given time; and of course an upper floor in concrete will need a flat platform wholly or partly in timber to support the concrete while it sets. More frequently, however, concrete lintels behind brick arches need shuttering for the bottom and inside, the surrounding brickwork having been brought to the required height.

The carpenter has to use his own initiative and make the best use of the timber available to put these shutters in position. Wet concrete can be very tricky material; it is about

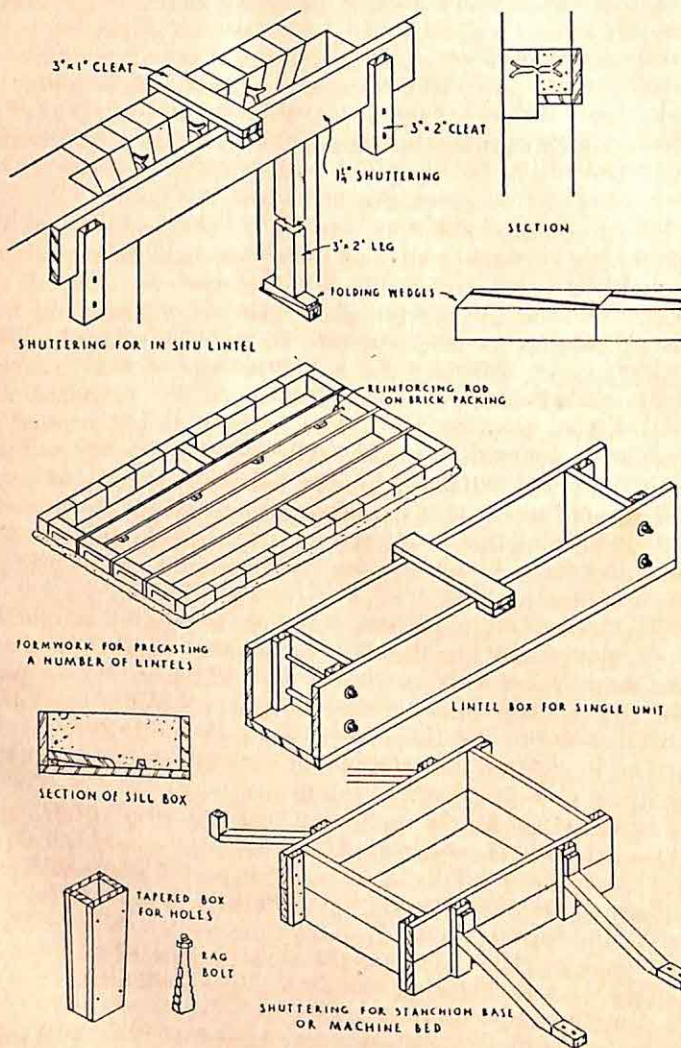


FIG. 103. FORMWORK FOR CONCRETE

two to two-and-a-half times as heavy as water and quite mobile. A chink or two between boards, however, is not so serious as it would be for water, because concrete is not usually made so that it will run. An important consideration is the "striking" or removal of the shuttering; the timber must be easy to remove when the concrete is set without damaging the work. Legs and struts should never be cut net length (to fill), for when striking the shuttering, the diagonal of the timber would then have to be forced past, putting a stress on the newly set concrete which might fracture it.

One more point about *in situ* work. Stanchion bases and beds for heavy machinery must have holes in suitable positions for holding-down bolts. These holes can be chipped out afterwards; but this is a laborious task, and a better way is to make provision for the concrete to be cast with the holes complete. For this purpose a hollow box of thin material lightly nailed together (Fig. 103) must be prepared and suspended in position while the concrete is put around it. When set, a cold chisel is used to destroy the thin box and pull it out. An inexperienced person has been known to use a solid piece of wood, nicely tapered for easy removal—but only once! The moisture from the concrete causes the wood to swell, and its removal is more troublesome than chipping a hole in concrete itself.

Wood moulds for precast concrete are quite simple for rectangular shapes like lintels; on the other hand they can be quite complicated when casting ornamental work, e.g. artificial stone for the face of a building having mouldings and other decorative work. For this type of work all decorative features must be in reverse, and the mould carefully made to take to pieces and re-assembled for further use.

When casting lintels on a building site (Fig. 103) a flat surface (say the site concrete) is selected and a brick surround laid down, with wood divisions lengthwise and bricks between, for various lengths of lintel. In this way a number can be cast at one operation and much time saved on individual mould making. The fact that the moulds must all be built up again for the next battery of lintels is not serious, as this can be quite quickly done.

For individual casting the box may have a bottom, two sides and two ends; or if a flat surface is available, it can be made

bottomless. In either case, ease of dismantling must be considered, and bolts or loose cleats used so that the box can be taken down without damaging it.

Bearing in mind that the upper surface of the concrete will always be level, the casting of sloping sills needs special treatment. The weathering slope will have to be at the bottom of the mould, and the various grooves and drips formed by fillets fixed inside or placed on top.

Whether the work is *in situ* or precast, reinforcement may be desirable. Briefly, concrete will withstand compression but not tension and units like lintels will, under load, tend to sag in the middle. The upper side will be in compression, the lower in tension. Therefore, the necessary reinforcement, usually of mild steel rods, is put in near the bottom to take the tensional stress. (In most cases one reinforcing rod of light section is put in near the top of precast units so that, if a unit is accidentally loaded the wrong way during handling, there is less danger of fracture.)

It will usually be sufficient to put pieces of brick of the required thickness at the bottom, place the rods in position and work the concrete carefully around them. A further purpose may be served by the pieces of brick—they enable a precast lintel to be put right way up (that is, reinforcement at the bottom) as identified by the brick pieces. Otherwise “Top” is scratched in the concrete while it is “green.” More complicated reinforcement may be suspended with wires.

ROOFS

Design of Roofs. Several considerations influence the form of roof and the type of construction suitable for a given building—

- (a) The plan of the building.
- (b) The span.
- (c) The support obtainable from neighbouring construction.
- (d) The kind of covering material to be used.

These items must be considered while developing the subject further.

TYPES OF ROOF (Fig. 104). *Lean-to.* When a roof of small span is to be put on an outbuilding, it is often convenient to rest the upper part of a single-slope roof against the main structure; thus the term “lean-to.” Suppose the outbuilding to be a garage, a suitable roof covering would be of the sheet

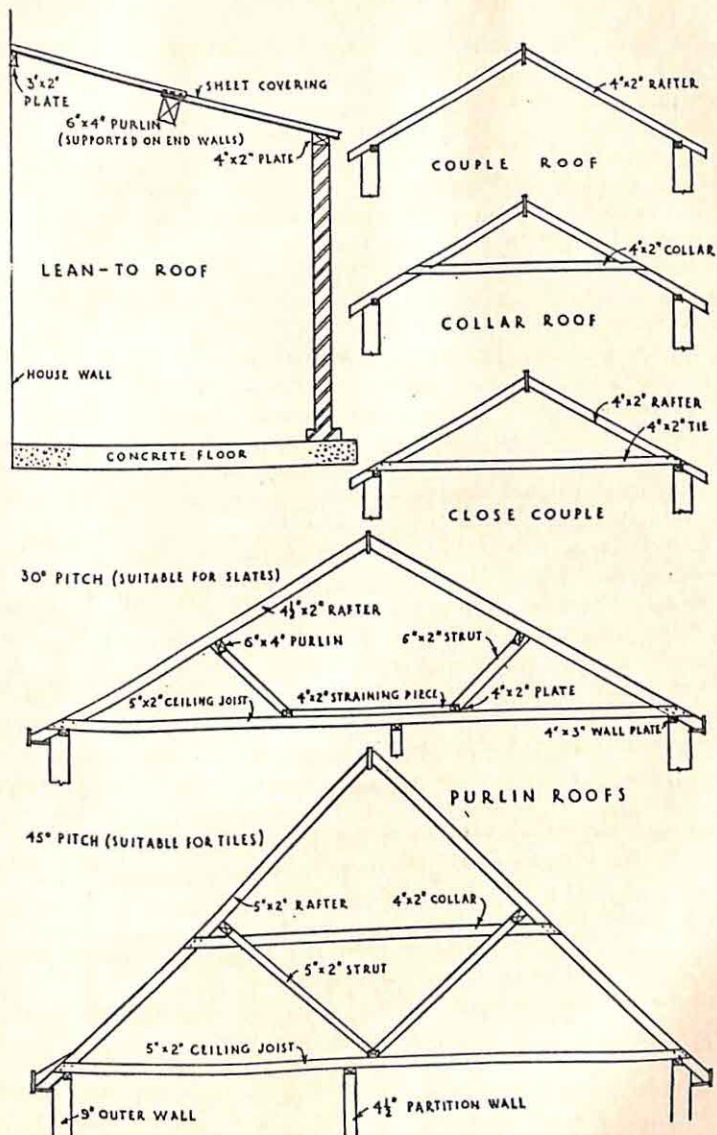


FIG. 104. TYPES OF PITCHED ROOF: SIMPLE SECTIONS

variety, say corrugated asbestos or iron. The corrugations serve to stiffen thin sheet materials.

All that is required in the way of support and fixings for these sheets is pieces of timber running the length of the roof. If one is attached to each wall forming wall plates, probably one extra support along the middle will be sufficient. The middle one called a purlin will find support at the ends only, so will need to be fairly stout. The sheets are nailed on with special galvanized screw-nails, having corkscrew grooves on them which grip into the groundwork tenaciously.

Couple. A small building standing by itself may be required to have a two-slope roof covered with small units of covering material like slates or tiles. These coverings need continuous support and frequent fixings. Battens running along the roof provide a solution. The battens in turn must be supported at frequent intervals by timbers called rafters which run with the slope of the roof. The amount of slope varies with the covering material, and the greater the slope the greater the area to be covered. It is economical, therefore, to use somewhere near the minimum slope permitted so as to avoid using an unnecessary amount of material. Slates need a slope of about 30° and plain tiles about 40° (both minimum angles). The rafters are fixed by nailing to the wall plate at the foot and to the ridge board at the top.

Couple-close. Obtain two pieces of lath and drive a round nail through them at one end to make a pair of compass legs. Stand them on the bench so that they are like a roof and press on top; the ends push outwards. Now the weight of roof coverings has the same effect, with the result that there is a tendency to push the supporting walls outwards. With light laths some bending would also be noticed. In order to counteract spreading, a piece of timber called a tie is fixed across the foot of each pair of rafters.

In a barn or shed these timbers provide a convenient rack for all kinds of implements and may be left uncovered.

If a ceiling is required, laths may be nailed to the ties for plaster-work or plasterboard fixed to them directly. In this case they serve a dual purpose and are known as ceiling joists. In addition, with strong enough timbers a floor may be put on and a loft formed. This roof would be suitable for a back addition to a house one room wide.

Collar. The tie in this case is put some way up the rafters. This arrangement enables an economy to be made in brickwork but the top corners of the room will be cut off; no great disadvantage in a box room. The collar-tie roof is not so efficient in resisting spreading as the tie at the foot of the rafters and there is also introduced a further tendency for the feet of the rafters to bend and spread; but for spans of 12 to 16 ft (depending on the slope or pitch) this type of roof should be satisfactory.

All the above-named roofs have been concerned with small spans or small isolated buildings.

Collar and Tie. We now come to roofs of respectable size. As the span increases, so does the length of the rafters; and intermediate stiffening becomes necessary. The collar and tie roof—often using ceiling joists as ties—is in common use for house roofs (see lower part of Fig. 104).

House Roof Construction. In dwelling-houses it is most desirable that the whole roof surface should be boarded. Often we find that in the interests of a cheap job it is not; with the following lamentable results—

- (a) Exposure of tanks housed in the roof.
- (b) Extreme variations of temperature—excessive heat in summer and cold in winter.
- (c) Penetration of dust and even powdered snow, particularly where roofs are tiled.

Boarding, felt, battens and tiles or slates may make a total load of 17 to 22 lb/sq. ft of roof surface; wind pressure and snow may produce up to 20 lb and 10 lb/sq. ft respectively. Evidently the roof construction to a normal house (see foot of Fig. 104 and top of Fig. 105) will need to be strong to withstand all this weight.

The commonly used components of a roof are rafters, ceiling joists, collars, purlins and struts. The purlins support the rafters at required intervals and must in turn be supported either by the party walls in a row of terrace houses (Fig. 105), or by struts from partition walls in semi-detached and detached houses (Fig. 104). Rafters and ceiling joists are placed 14 to 18 in. centre to centre, collars fixed to every pair (or every second, third or fourth pair) of rafters as may be required and struts about every fourth or fifth pair.

Where a single large room is required the intermediate

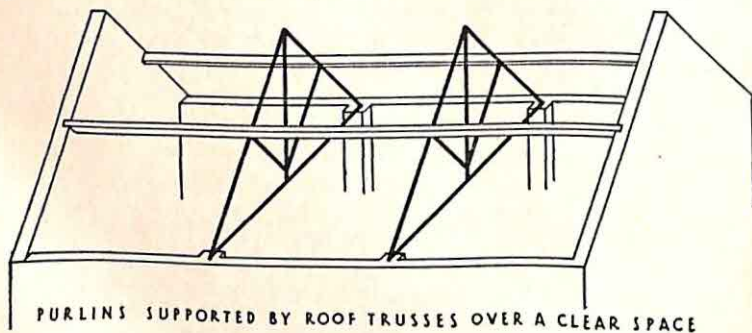
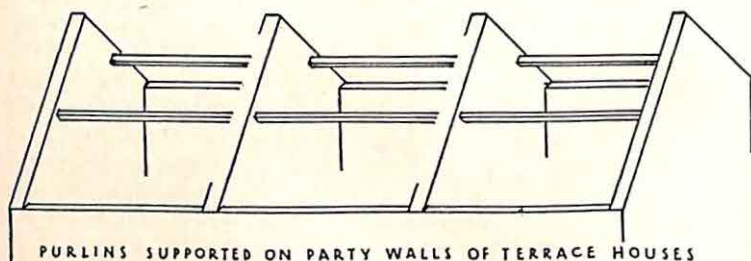
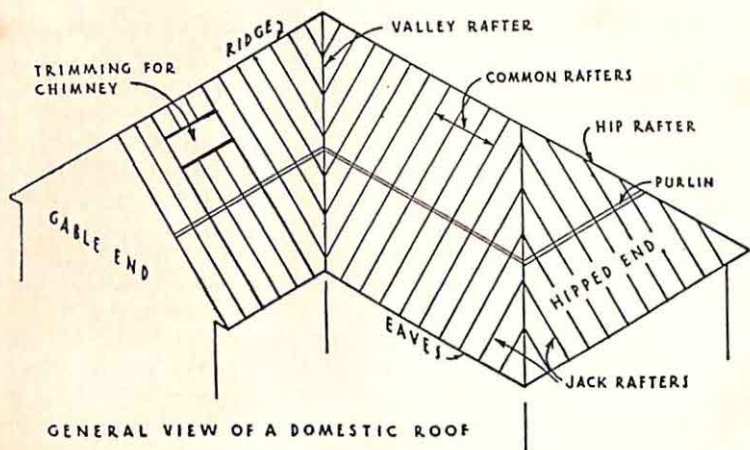


FIG. 105. ROOFS: FORM AND ARRANGEMENT

supports to the roof timbers may be provided by triangular frames called *trusses* as shown in the lower part of Fig. 105.

Gables, Hips and Valleys. When an outside wall of a building is carried up until it meets the roof slopes, it forms a triangular mass of walling known as a *gable*; this receives the outer edges of the roof slopes, which usually overhang a little. The complete structure—walling and roof finishes—is called a *gable end*.

Instead of carrying up the wall to the shape of the roof section, another slope is often formed as shown in Fig. 105, springing from the level eaves. In the examples shown the end is at 90° , in plan, to the side eaves. The portion of roof so formed is called a *hipped end*. In the construction a large timber, called a hip rafter, is placed at the intersection of the two roof slopes. The line of intersection is called the *hip* and it forms a sharp edge on the outside.

When two roof slopes cut each other from two parts of the building running in different directions they form a *valley*. The sharp edge of this intersection is on the inside. As with the hip, a large timber is used to form the line of the valley; it should be noted that both hips and valleys support rafters which are cut and fitted against them and secured by spiking with large nails.

Hips and valleys in a roof bring problems in construction which need a knowledge of geometry. As a first step towards this knowledge every student will have made the approach through a separate course in practical geometry. In Fig. 106, however, there are assembled all the direct problems which are capable of solution at this stage illustrated by a cut and folded model; the construction is dealt with later.

Bevels are slopes for cutting the rafters. The meaning and purpose of the various bevels should be clear if comparison is made with Fig. 105, which also illustrates the general arrangement of the timber construction.

GEOMETRY OF THE HIPPED ROOF. The plan and elevation are drawn first (Fig. 106) and the length and bevels for the common rafters are shown at the end of the elevation.

On the plan set the length of the common rafter perpendicular to both sides and both ends of the plan, and project the line of the ridge to meet; join the points so obtained with the corners of the plan. In effect both sides and ends have now

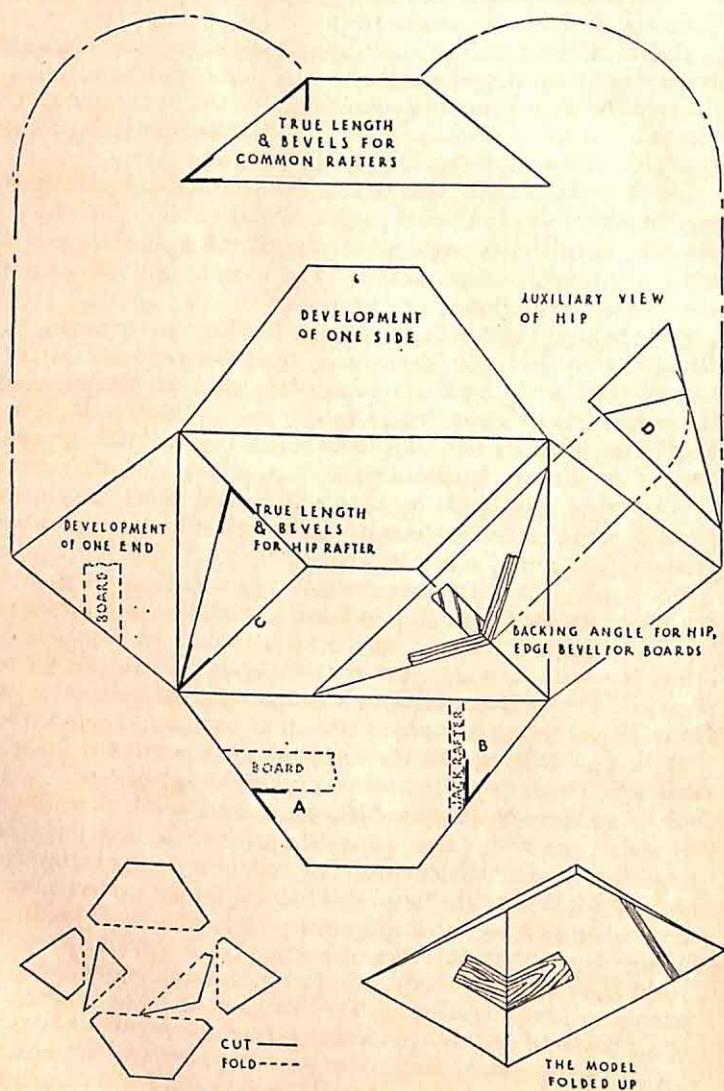


FIG. 106. HIPPED ROOF MODEL

been swung outwards and laid flat on a horizontal plane and their true shapes obtained.

The face bevel for cutting the roof boarding is shown at *A*, and a line taken perpendicular to one side of the plan to meet the hip line at *B* gives the edge bevel for the jack rafters. The top and bottom cuts (*plumb* and *sole* cuts respectively) for the jack rafters are the same as for the common rafters.

To find the length and bevels for the hip rafters, set the height (the *rise*) of the roof perpendicular to the plan length of the hip, form the triangle as at *C*, and the hypotenuse of the triangle is the required length. The plumb and sole cuts are the two acute angles of the triangle.

For shaping the hips and mitring the boarded covering it is necessary to find the angle contained between an adjacent side and end of the roof. Suppose a saw cut to be taken through these surfaces at right angles to the line of the hip, a piece of cardboard pushed through, and lines drawn with a pencil resting on the two surfaces. The edge of the hip rafter should be planed to the angle so obtained (called a *dihedral* angle), so that the boards rest snugly on it. Half this angle is used as the edge bevel for the boards.

To obtain this angle geometrically, an auxiliary view of the hip is set up at *D*, its rise and run completing a right-angled triangle identical with *C*. A line drawn at right angles to the hip represents an edge view of the piece of cardboard pushed through. Its horizontal length is found by projection across the plan. By swinging the edge view on to the plan, the complete triangle is obtained, and the angle at the apex is the dihedral angle (the angle between the two adjacent surfaces).

The two smaller diagrams show a useful method of testing the above method. The whole shape may be cut out; but by leaving small corners on, the model will hang together. The "dihedral triangle" and the hip are folded up to fit under the sides and ends; boarding and jack rafters may be drawn to show where they fit. (See also page 55, Fig. 28.)

Roof Coverings. The lay-out of a roof is largely influenced by the choice of material used for covering it. For reasons of economy a roof is pitched at the minimum permissible slope for a given material; since the greater the angle of slope to the horizontal, the more material of every kind will be needed and, due to increased weight, the stronger will have to be the

supporting structure. Roof covering materials which are in large pieces and impervious to the penetration of water may be laid almost flat, the fall being sufficient to ensure that the water runs off freely. Among these are lead, zinc, and asphalt and the flexible sheets. Flat roofs may be of timber construction or of concrete.

Materials which are used in small units, each piece overlapping the one below it on the roof, must be laid at such an angle that the risk of wind getting underneath and ripping them off is minimized. Slates, being flat, lie closely together and may be laid to an angle of 25° to 35° ; the larger the slate the shallower the pitch. Due to smaller size and less regular shape, tiles are wisely laid to a minimum angle of 40° .

Besides keeping out rainwater, a domestic roof is required to exclude wind, snow and dust; this is not so important in the case of a barn, cowshed, or similar building. For this purpose, slates or tiles simply fixed to battens and rafters and without pointing or torching, are inadequate. Proof of this contention is found in any roof lacking additional covering, particularly when powdered snow is being blown by the wind; but frozen tanks and pipes and accumulated dust are also good indications.

Various means have been, or are being, tried to exclude snow, wind and dust. The spaces between units can be pointed with mortar from the underside; roofing felt and other rolled materials can be laid on the top of the rafters before the battens are put on, but a roof which is boarded and has also a layer of good roofing felt fulfils all the requirements.

On very large roofs, liable to great wind pressure, the boarding may be laid diagonally across the rafters with a view to bracing the whole structure. Another refinement sometimes employed consists in fixing the roofing felt to the boarding with battens laid up the slope of the roof, the slating or tiling battens being subsequently fixed across these to receive the covering. This method is employed to obviate any chance moisture being held behind battens laid horizontally on the felt. Feather-edged boards are sometimes used as in Fig. 107. The thick edges are placed at the top so that tiles can be hung over them. The method is fairly satisfactory with good boards but chance breakages and the leakage of water to the boarding results in it passing to the interior.

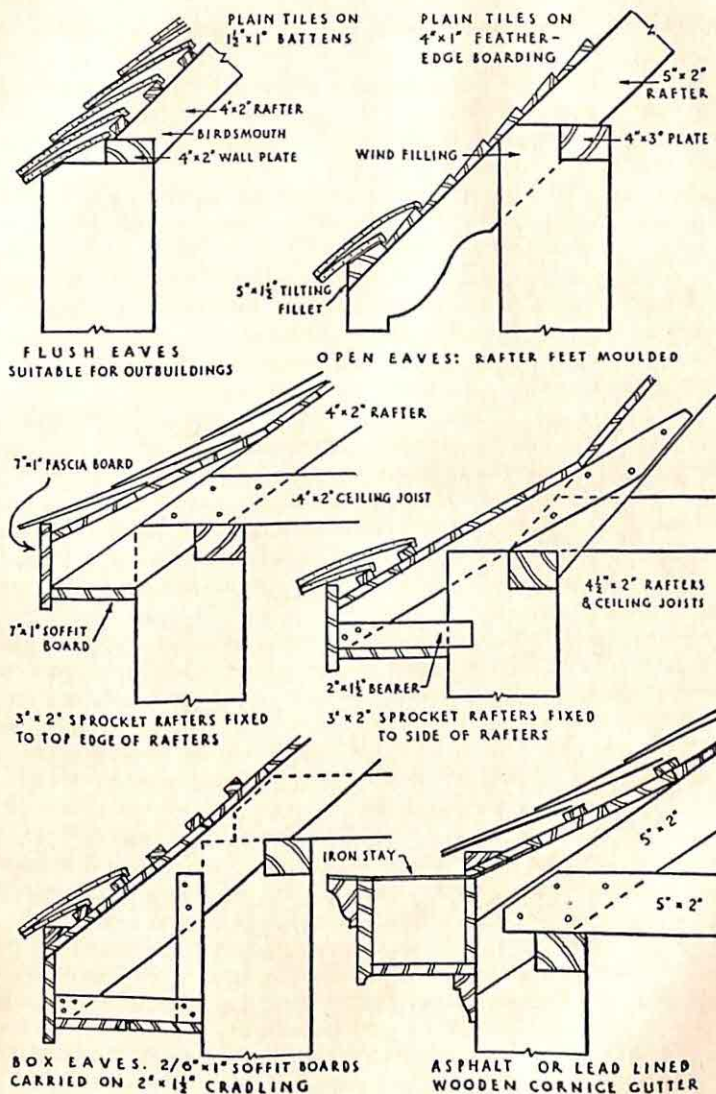


FIG. 107. EAVES CONSTRUCTION

Carpenters' Work. Usually the carpenters' work finishes with the fixing of roof boarding; but they may be required to put on the roofing felt and even the battens for tiles or slates, though normally the slaters and tilers do this part of the work.

In preparing for the roof covering a *tilting fillet* is the first consideration; its function is to tilt the under-eaves course of slates or tiles so that they fit tightly under the first full-length units. The fillet may be a piece of triangular section, formed by ripping a rectangular section across its diagonal; or the fascia board may be made wide enough to stand above the line of battens.

The next member to be fixed is the second batten, its appropriate position being obtained from the slater and tiler. The rest of the battens are then fixed straight and parallel, at a gauge (from centre to centre, or back edge to back edge) again determined by the man who is to lay the final coverings.

Construction at Eaves. The eaves is the lowest part of the roof, usually, but not necessarily, oversailing the outside wall. The design and construction of the eaves is important because all rain falling on the roof makes its way to this part, being most often run away by means of gutters and down pipes. The eaves also protects the upper portion of the walls from becoming wet and, if well constructed, prevents wind entering the roof. An architect will, at times, use extra deep eaves to lend character to a building; and in tropical climates, rain is diverted and sun prevented from striking windows immediately below by the same means.

Wall plates are fixed straight and level to the top of the wall; if mortar is used for bedding, it should be mixed with a minimum of water or the timber will become wet and in this position it may become liable to attack from dry rot.

Large nails (spikes) are used to fix the roof timbers to the wall plates. The ceiling joists will later be spiked to the plates, preventing the tendency of the rafters to push the wall plates outwards.

There are several alternative methods of finishing the foot of the rafters (Fig. 107)—

(1) A *birdsmouth* is made which fits around the wall plate. In this case the eaves may be flush with the brickwork, or additional sprocket rafters may be used.

(2) The rafters oversail the wall and have their ends

exposed to view. In this case the ends may be wrought (planed) and possibly moulded as well. A notch cut on the underside of the rafter positions it on the plate and again large nails are used for fixing.

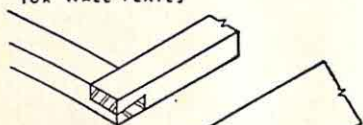
(3) The most common treatment is to arrange for the feet of the rafters to oversail the wall and fix the fascia and soffit boards to them, boxing them in entirely. Hence the term *box eaves*. Where insufficient fixing is afforded to these boards by the rafter feet, separate bearers or *cradling pieces* may be used for holding the soffit board.

Cast-iron gutters are usually employed and fixed to the fascia or to the rafter feet; very large buildings may need an outsize in gutters to carry away the great amount of water collected by the extensive roof surface. Quite often a stone cornice will be used to support the gutter, or the stonework may itself be hollowed out and lined with lead or asphalt. An interesting alternative is the wooden cornice, suitably lined with lead or asphalt. This may at first appear old-fashioned, but many modern buildings have this feature; and it is worth noting that in Canada and the U.S.A. the weather-resistant Western Red Cedar is used to make gutters which are not lined in any way.

Support for Hip Rafters. The outward thrust at the feet of common rafters is held by the ties or collars, but some other means must be found to prevent the foot of the hip pushing diagonally outwards. One method consists in cutting a *throat* in the underside of the hip (Fig. 108), the outer edge of the throat keeping the wall plate tightly together. If the hip does not oversail the wall plate a brace is put across the corners, half-lap dovetail joints being used.

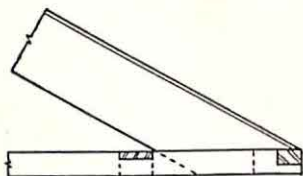
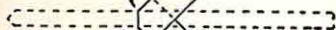
On large roofs, the weight of roofing materials causes increased thrust at the foot of the hip, and if this pressure were to be transmitted directly to the corner of the wall plate, it would increase the liability to failure at that point. For this reason a heavy angle tie is used in conjunction with an additional member, known variously as a *dragon tie*, *dragon beam* or *dragon piece* (see lower diagrams, Fig. 108). Both members should be of about 6 in. $\times$ 4 in. timber on edge. The angle tie is coggled over the wall plate, very little material being removed from the latter, and the ends of the tie are allowed to run 6 in. or more over the outer edge of the plates. The dragon

SPLAYED HALVING
FOR WALL PLATES

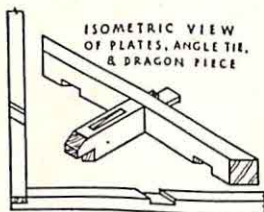
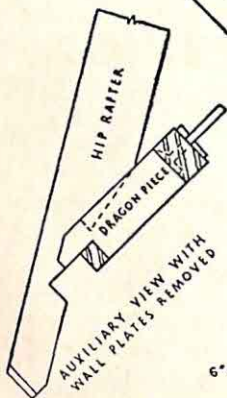
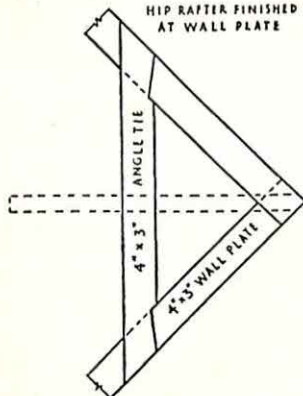


ELEVATION OF HIP RAFTER
OVERSAILING AT EAVES

PLAN OF WALL PLATES
WITH CORNER CUT OFF



HIP RAFTER FINISHED
AT WALL PLATE



ISOMETRIC VIEW
OF PLATES, ANGLE TIE,
& DRAGON PIECE

DRAGON-TIE JOINT

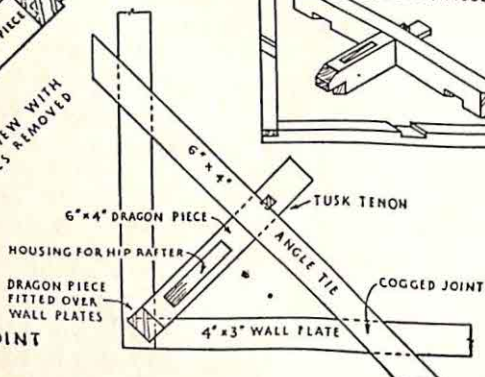


FIG. 108. TIES AND SUPPORT TO FOOT OF HIP RAFTER

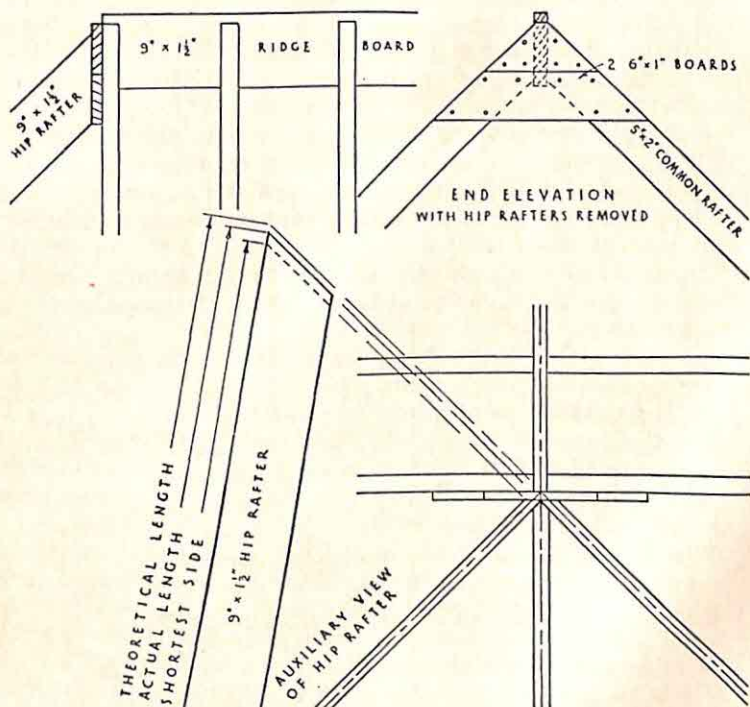
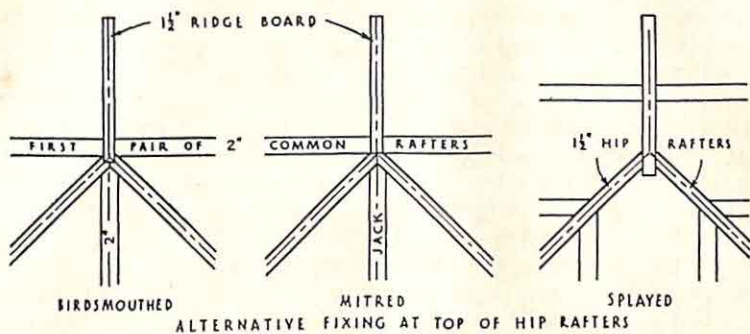


FIG. 109. PLACING AND FIXING HEAD OF HIP RAFTER

piece, which actually supports the foot of the rafter, is secured firmly to the angle tie with a tusk tenon joint and its other end cut to fit around the corner of the plates. An inclined slot in the top edge of the dragon piece receives a suitably shaped tenon on the end of the hip rafter. It is not necessary to make shoulders to this tenon—it is much stronger when made the full thickness of the hip. By making the end of the tenon vertical the tendency for it to slide out is avoided. Bolts or nails should not be needed.

Valley rafters do not create any problem of this kind, since the wall plates are pushed together at the corner and the ties or ceiling joists hold any thrust quite effectively.

Fig. 109 shows the various methods of cutting and securing the hip rafters at the head, where they meet the end of the ridge. The splayed side connection to the ridge and the use of cleating boards are the better methods. The splay for the top end cut of the hip is also shown in the lower diagram (cleated example).

Wind Filling. This is the name given to the brickwork built in between the rafter feet after they are fixed. Its purpose is to fill up the spaces between the rafters from the wall plate to the boarding and so prevent blasts of cold air from entering the roof space.

Sprocket rafters are short lengths of timber nailed either to the side or to the top edge of the rafters with one or more of the following objects in view—

(a) to improve the appearance of the roof by adding a sweeping curve at the bottom:

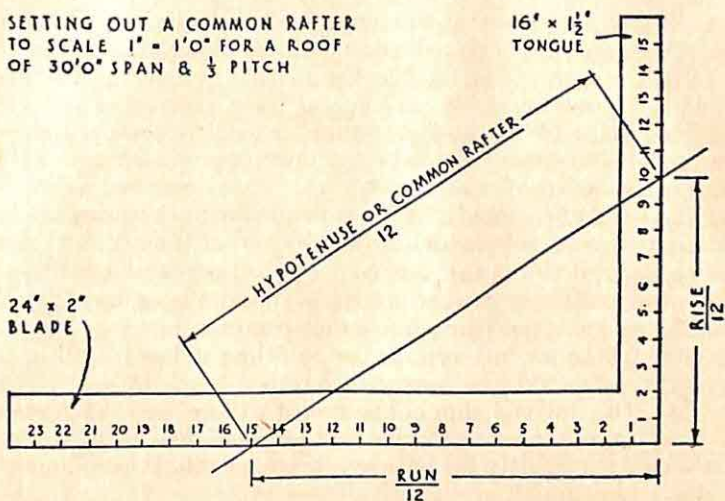
(b) to slow the flow of rainwater down the roof just before it enters the gutter;

(c) to avoid having to order specially long and expensive timber for rafters when short lengths are available for making the over-sailing portions.

The Steel Square. When part of a model roof has been constructed from scale or full-size drawings, it will be a useful exercise if some of the members required are then set out with the aid of the steel square (Fig. 110). A simple introduction of the instrument is intended here for a rectangular plan.

Begin with a simple member, a common rafter. The run is taken along the blade of the square, and the rise along the tongue (to scale 1 in. = 1 ft). The hypotenuse of this

SETTING OUT A COMMON RAFTER
TO SCALE 1" = 1'0" FOR A ROOF
OF 30'0" SPAN & $\frac{1}{2}$ PITCH



SETTING OUT A FULL SIZE
RAFTER BY MARKING THE
LENGTH 12 TIMES ALONG
THE TIMBER
NOTE - THE END MARKS
ARE THE BEVELS

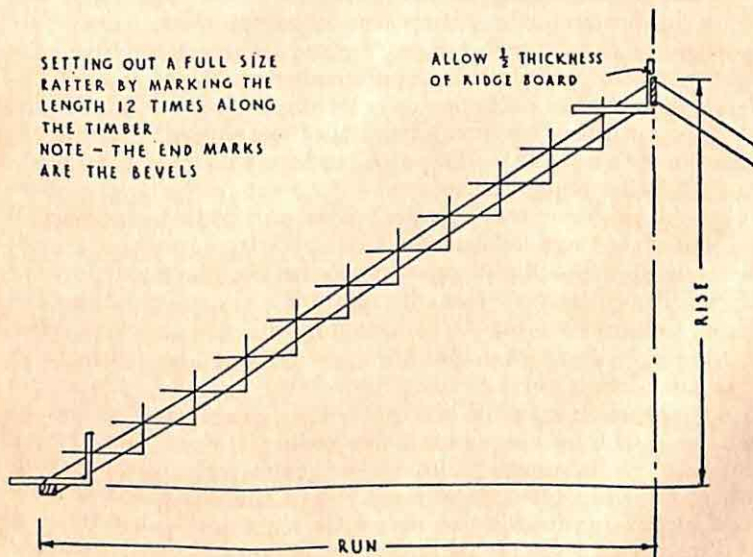


FIG. 110. THE STEEL SQUARE AND ITS GENERAL USE

right-angled triangle is the length of the common rafter, and if this length is marked twelve times along the timber, its correct length is found. The end marks (angles at the ends of the hypotenuse) are the bevels.

The principle of the steel square is as easy to apply as this example indicates. Fig. 111 shows the several operations for determining lengths and bevels which are described below.

To obtain the length of the hip, two operations are needed. It is necessary first to determine the run of the hip, by taking the run of a common rafter along both tongue and blade, the hypotenuse being the correct run. This run is taken along the blade and the rise (the same as for common rafters) along the tongue; the second hypotenuse so found is the length of the hip, and the end marks are the bevels.

By studying the plan of the roof it will be seen that the run of a jack rafter is the same as its perpendicular distance from the corner. Put in another way, this means that the amount by which the run of any jack rafter is shortened is the same as its distance (centre to centre) from its neighbour. The usual procedure therefore is *to determine by how much the longest jack is shorter than a common rafter* and subtract this amount (by measurement) from each successive smaller jack.

The method of obtaining edge bevels for jack and hip rafters will be most easily appreciated if the steel square is laid on the roof in such a way that the edge cut forms the hypotenuse of a right-angled triangle, the arms of the square being the other two sides. For example, when the square is laid on the roof-slope with the blade along a jack rafter, and the tongue parallel to the wall plate, the hypotenuse will be formed by the hip line. This gives the edge bevel for the jack rafters; in steel square parlance this is expressed as: $\text{run of common rafter by}^* \text{length of common rafter} = \text{bevel for jack rafters}$.

The edge bevel for the hip rafter is now available (for application on an edge planed to the backing angle) and, in addition, the face bevel for the boarding. Lengths and bevels for valley rafters and valley jacks are determined in the same way as for hip rafters and jacks.

A deduction must be made for the thickness of the ridge on all rafters. This is best done separately on a full-size drawing.

* The word "by" must not be confused with "multiplied by." It denotes "with" or "in the presence of."

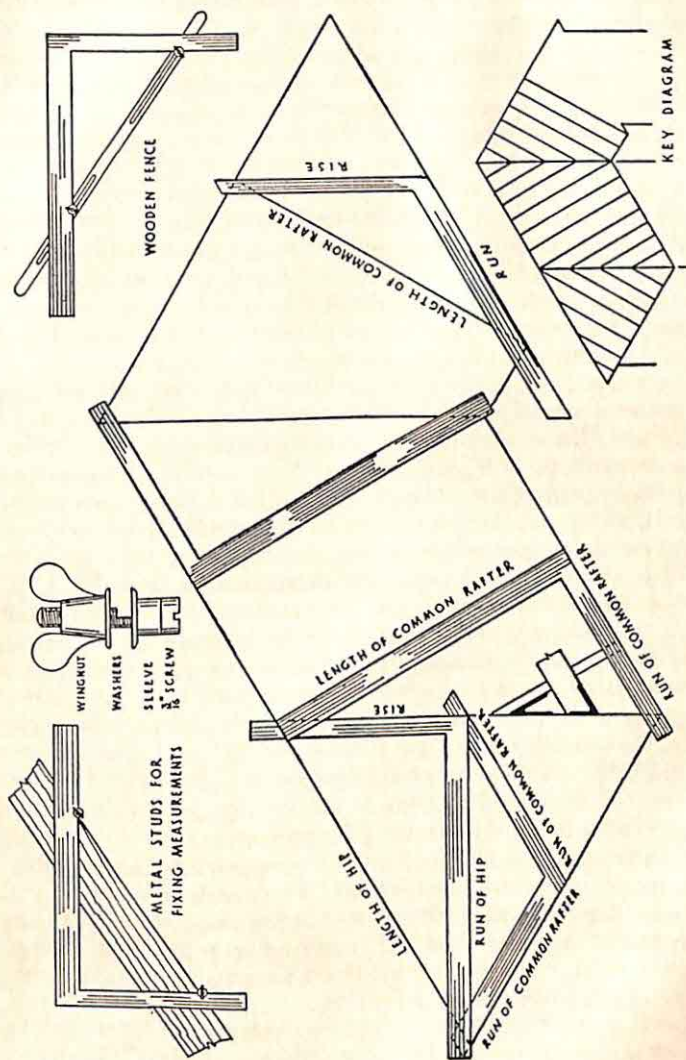


FIG. 111. USE OF STEEL SQUARE IN PREPARING HIP AND VALLEY ROOFS

The method of finding purlin bevels, edge bevel for boards and the backing angle for the hip rafter by means of the steel square are best left to a later stage in a senior course.

A practised craftsman obtains true lengths and bevels with this tool wherever its use is convenient. This is true not only in roof work; it is particularly useful for setting out stair strings. Finally, the length of any inclined line may be determined using the principle embodied in the steel square; i.e. horizontal run by* perpendicular rise = true length. The metal studs and slotted bars are for fixing measurements.

Trussed Roofs. So far, we have dealt with roofs having small spans or supports near the middle. In a hall or other public building, neither of these conditions obtains. The roof has to span a wide clear space and must be so constructed as to be a self-contained unit merely resting on the outside walls.

For this purpose, a triangular framework or *truss* is placed at 8 to 12 ft intervals underneath the purlins to give them the necessary support. The design of the truss depends on the number of purlins to be supported; and, of course, the number of purlins depends upon the length of the common rafters. Where only one purlin is required on each slope, the form of truss called a king post truss will be suitable.

KING POST TRUSS (Fig. 112). The three sides of the triangular framework consist of two principal rafters and a tie beam, the latter preventing the feet of the principal rafters from spreading outwards. Being heavy, the tie beam will have a tendency to sag; to counteract this, the king post and *gib and cotter strap* (Fig. 113), pick up the weight at the middle point. The purlins transmit the weight of the roof coverings to the middle point of the principal rafters, so that the latter will be liable to bend. To prevent this, struts are put in which transmit the weight to the lower end of the king post.

We may now consider the kind of stress (internal force) in each member. The tie beam is pulling inwards and is therefore in tension. The king post hanging from the apex of the triangle is holding tie beam and struts near its bottom end and is therefore in tension. Principal rafters will be in compression, for the king post is putting a load on the top ends, while the square abutment at the bottom resists the thrust. The struts are loaded similarly and will be in compression.

* See footnote on page 234.

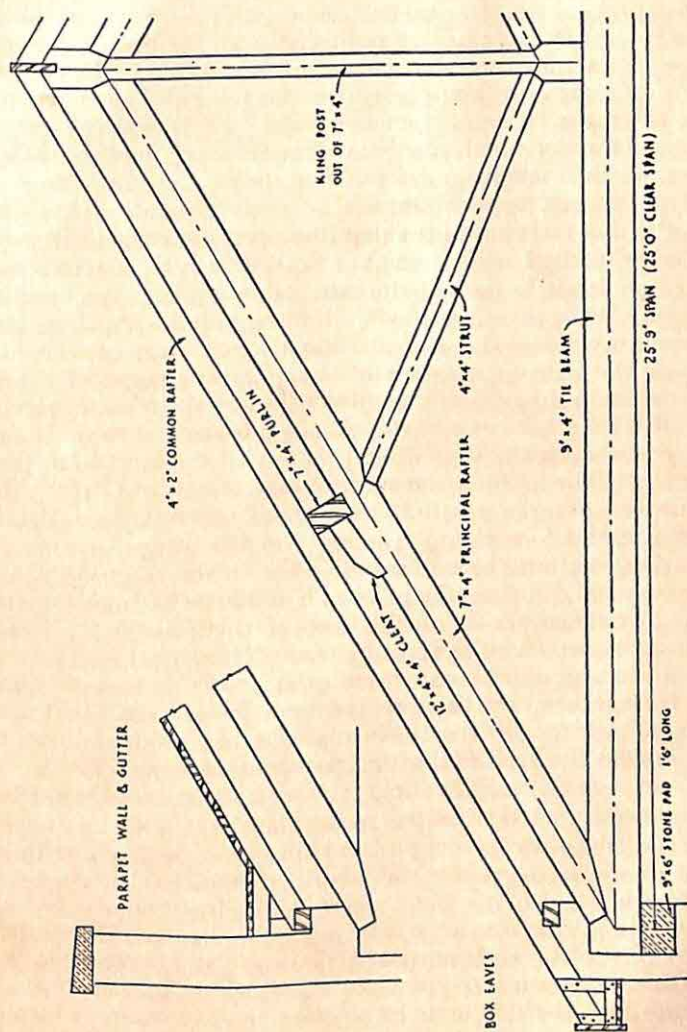


FIG. 112. KING POST ROOF TRUSS

Joints (Fig. 113). Each member will transmit loads along its length and the most effective way of supporting these loads is to transmit them at right angles to the line of action. Therefore each joint has a square abutment as far as the centre line of the member and thereafter the joint line is taken to meet the intersection of the edges.

A minimum of material only must be removed in forming the joints, so that members are not unduly weakened. Where a joint is in compression, it will be pushed together by the forces acting on it and, provided it is prevented from slipping out sideways by being tenoned or bridled, will be effective.

If the joint is being pulled apart, its design is not so easy if one still bears in mind the need for minimum cutting. It becomes necessary, therefore, to employ steel straps at certain joints. The joint at the foot of the king post merely locates its position in the beam. The gib and cotter strap is employed to pull the tie beam upwards. About $\frac{1}{2}$ in. clearance must be allowed between the top gib and the top of the mortise in the king post; then, when the wedges (or cotters) are driven in from both sides, the strap and tie beam can travel upwards and bring the shoulder tight. The slots in the straps are made extra long so that the bottom gib rests on the mortise in the king post, and provides the point of reaction for the movement.

To obviate the risk of the feet of the principal rafters shearing a piece off the end of the tie beam by their thrust, stirrup straps are placed round the joints to keep them tightly together and to provide extra resistance. The least important straps are the three-way examples used to prevent the joints at the head of the king post from moving.

WOOD AND STEEL TRUSSES. Timber roof trusses are fairly expensive compared with steel ones. They have the advantage, however, that they have a pleasing appearance where a ceiling is not used and the roof remains open. They are still the best for churches and public halls where the roof will be the object of attention (for example, during sermons or speeches!). For purely utilitarian purposes, however, the steel truss is cheaper and easier to make; and for swimming baths, factories and the like, and in places where a ceiling is to be put in, it is a more likely choice.

To combine reasonably good appearance with cheapness and efficiency, part wood and part steel trusses are used, the

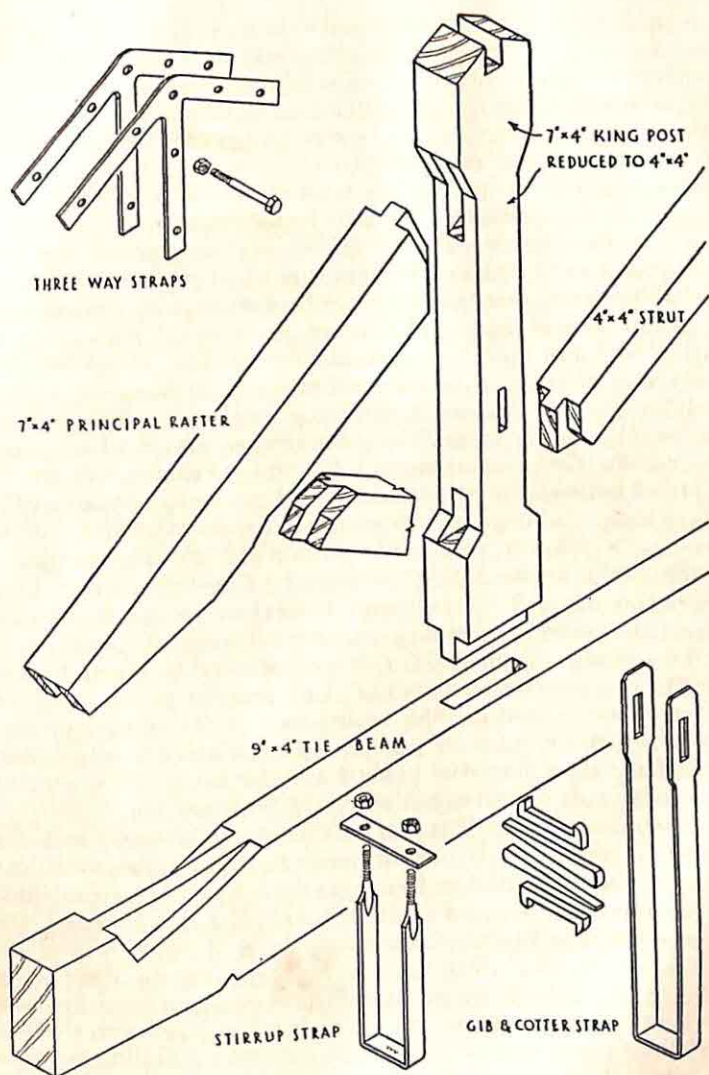


FIG. 113. JOINTS IN KING POST TRUSS

principal rafters being timber and the tension members round steel rods. Steel being of greater strength than timber, only slender rods are needed; hence the appearance is lighter.

Flat Roofs. Flat roofs may be formed of timber joists and boards covered by lead; or of concrete, covered with a variety of materials, most commonly asphalt. Carpenters' work in connection with a flat roof of concrete consists in forming a temporary flat platform of boards (shuttering) upon which the concrete can be placed; the boards and supporting timbers being removed by the carpenter when the concrete has set.

The timber groundwork for lead covering necessitates considerably more labour and skill and its cost, along with that of the lead and the plumber's labour, is tending to make this type of work prohibitive on any but small surfaces or superior building work. Less expensive coverings which require similar timber groundwork include copper, zinc, and asphalt.

Lead or other sheet metal flats may, however, still be justified under such circumstances as follows—

(1) Small roof areas to dormer or bay windows, and porches.

(2) A flat top to a large pitched roof, used to save a high ridge line either for architectural effect or to gain light in a street or garden. In addition lantern lights may be required or even a place from which to view surrounding country.

(3) On a one-storey building like a shop or garage, where a pitched roof would conflict with windows. (It may be noted that in a shopping street, increased light and air is obtained by setting the upper part of the buildings back, thus requiring flat roofs over one-storey shops.)

LEAD FLAT (Fig. 114). If any considerable area is to be covered, it must be divided into *bays* so that each sheet of lead is easily handled, and so that expansion and contraction (due to temperature changes) can take place freely without the sheets buckling and wrinkling.

The whole roof must be laid to a fall of at least $1\frac{1}{2}$ in. in 10 ft towards the gutter. The boards must run in this direction so that any possible warping of them merely makes ridges parallel to the flow of the water. If laid across the flow the water might form puddles against any slight unevennesses.

One long edge and one short edge of each sheet is fixed, and the other two edges left free to move. The carpenter fixes wood

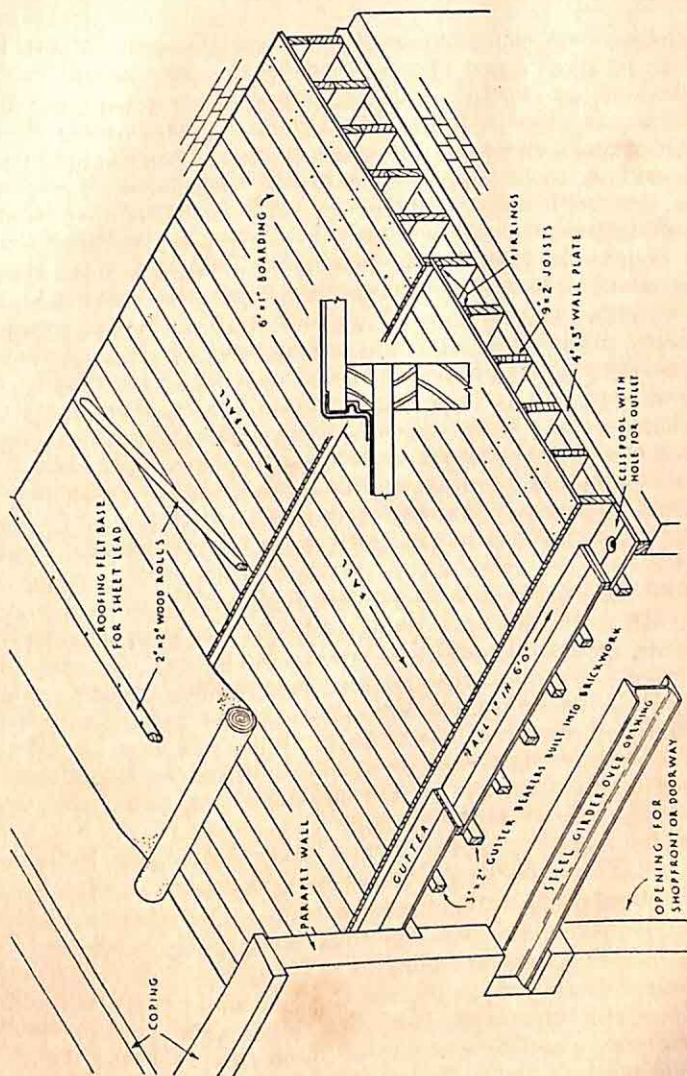


FIG. 114. TIMBER FRAMED, LEAD-COVERED FLAT ROOF

rolls in the direction of the fall, and over them the plumber dresses the sheet metal.

Joints across the flow are made by stepping down 2 in. or more; these steps are called drips. The last downward step takes the water into a gutter which is made 12 in. wide, with bearers and boards and constructed with fall and drips like the flat itself. At the lower end the water is collected in a cesspool and hence led away to a rainwater pipe.

The timber-work to a lead flat closely resembles that to an ordinary floor (Fig. 114). The joists are supported at each end on wall plates resting on the brickwork, but each joist needs a strip of wood (*a furring piece*) fixed to its top edge to form the slope or fall. Each succeeding furring piece, working from the bottom end upwards, must be thicker than the last; by reason of the drips they may become very deep towards the top end. An alternative is to step the wall plate up at each drip, but this causes the ceiling to step up too.

On the best work a layer of roofing felt is laid on top of the boarding by the carpenter. This felt is butt-jointed under the wood rolls, and forms a smooth surface as a base for the sheet lead. Movement of the lead is made easier and any risk of wrinkling and buckling minimized.

At drips, the upper surface of the boards must be rebated so that the lead under cloak is flush with the surface, and a capillary groove in the vertical portion prevents moisture creeping between the lead sheets and into the woodwork.

SECTION VI

STAIRS

STAIR construction is usually viewed as a section of joinery for advanced study. There are many craft difficulties concerned with stairs; but the introductory study presented in this chapter should be within the range of a third year junior student who has completed the earlier sections of his course with credit.

A stair provides the commonest means of transit from one floor level to another. It may be simply arranged and simply constructed, or it may be designed and executed in elaborate detail. Stairs have received the special attention of architectural designers and there are many beautiful examples of traditional types, generally having distinctive features of the period of history to which they belong. The treatment given here relates only to the simplest examples of modern work in which the stairs and handrails are of wood.

The main terms with which the student must become familiar are—

Staircase. The space allotted to contain the stair.

Stair. An assemblage of steps.

Flight. One straight run of steps.

Step. The unit on which the foot is supported. A wooden step consists of two parts—the flat board to receive the foot, called a *tread*; and the vertical board closing the space under the tread and giving support to it, called a *riser*.

In climbing a stair the movement is upwards and forwards. The measure of the upward movement is called the *rise*, and the measure of the forward movement the *going*. Other explanations are given as the terms arise.

Wood Stairs. The simplest type of stair consists of two steeply inclined planks (called strings) with stout horizontal pieces (treads) grooved into them, enabling the user to climb from one floor to the next, grasping the sides hand over hand for support. Very little horizontal space is taken up, and the arrangement is quite suitable for barns, warehouses and certain parts of ships where something more substantial and permanent than a ladder is required. It should be noted that the steep

angle of the stair will necessitate the user descending backwards, since the feet must be placed between two treads. On the other hand, a stair which is designed to ensure maximum dignity and grace to the users must have long shallow steps. Examples are to be found in large public buildings used for ceremonial purposes. A good example is St Paul's Cathedral. Compare the two examples in Fig. 115.

A steep stair gets one quickly from one level to another with minimum horizontal travel, but with much effort and little comfort. A shallow stair gets one slowly from level to level, with considerable horizontal travel, but comfortably and safely. Somewhere between the two extremes comes the ordinary domestic stair. The steepest angle desirable is considered to be 42° , and as a shallower angle causes the stair to occupy space which could be put to other uses, 42° to the horizontal, or very little less, must be the aim.

The horizontal distance travelled by a flight of steps is called the *total GOING* (or *run*) and vertical distance the *total RISE* (or *lift*). The going and rise for each step is determined by the formula, $2R + G = 22\frac{1}{2}$ in. to $23\frac{1}{2}$ in. The length of the average adult stride, walking comfortably on the level, is about 23 in. Going up hill the pace is shortened; the upward lift is reckoned to be twice as difficult as the horizontal movement.

Thus $2 \times \text{rise} + \text{going} = \text{normal step}$.

Example 1—

Rise = 7 in.

Going = 9 in.

$$(2 \times 7) + 9 \text{ in.} = 23 \text{ in.}$$

Example 2—

Rise = 6 in.

Going = 11 in.

$$(2 \times 6) + 11 \text{ in.} = 23 \text{ in.}$$

The hypotenuse of a 9 in. $\times$ 7 in. triangle = 11.4 in. and of an 11 in. $\times$ 6 in. triangle, 12.5 in. The formula therefore shortens the pace as the angle increases, which is quite appropriate.

So far only the angle and the ratio of rise and going have been considered. Headroom is also important. The minimum

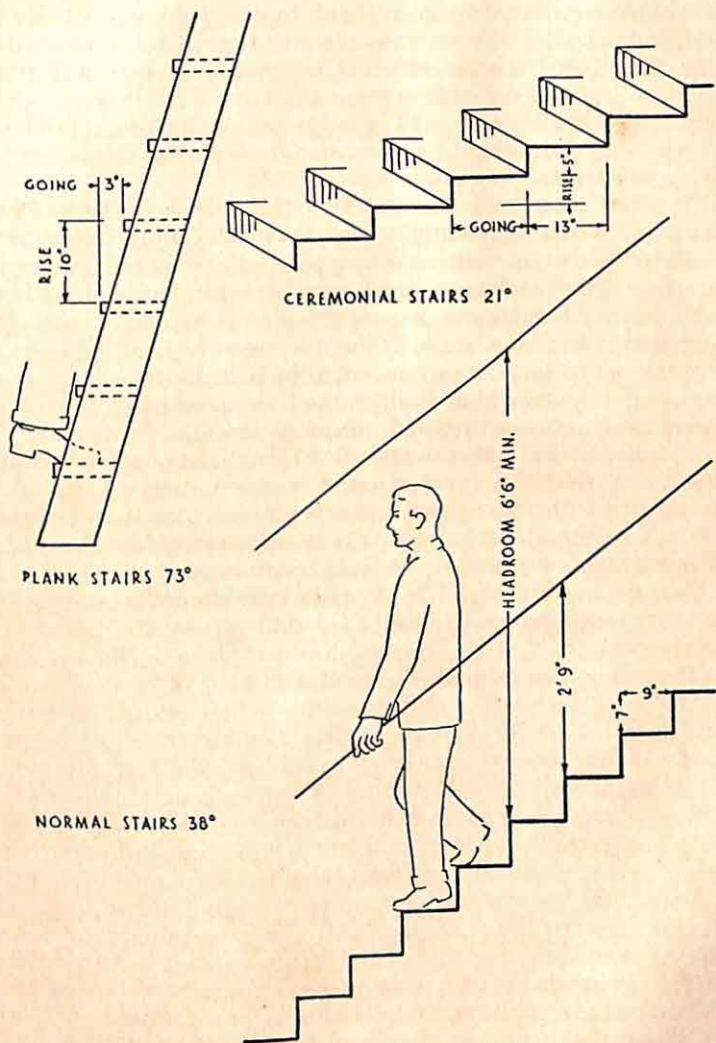


FIG. 115. DESIGN OF STAIRS: EASY AND DIFFICULT ASCENT

clear space required from a tread to the ceiling or soffit is 6 ft 6 in. and this height must be measured over a riser face (see Fig. 106). The minimum handrail height is 2 ft 9 in. also measured over a riser face and is to 3 ft on landings measured above the floor. The balusters should be so designed that a baby cannot get its head wedged between them; $3\frac{1}{2}$ in. is the maximum desirable spacing.

Suppose the shell of a building (i.e. walls and floors) has been built and the opening in the upper floor suitably trimmed. A storey rod is prepared for the height by cutting a piece of batten net length from floor to floor. The total available going is also measured; the stairs can then be made to fit accurately. The design of the stairs will have been considered as correct from the drawing stage onwards, but a final check is very desirable to ensure that no mistake has been made.

In the Southern method of procedure the storey rod is accurately divided, and the number of steps made accordingly, consisting each of a tread and a riser (see bottom of Fig. 116). The riser serves two useful purposes—it fills an otherwise ugly and possibly dangerous gap between treads, and it stiffens and supports the treads, enabling thinner material to be used for them. The several methods of arranging the construction of steps in Fig. 116 should be noted.

The assembled steps are put on one side while the housings in the strings are formed (Figs. 117 and 118). The ends of the strings are tenoned and fitted into mortises in the newel posts. When all is ready, the stair is assembled by placing one string on the bench, inserting the ends of the steps into the housings, placing the other string on top, and applying pressure, while the wedges are glued and driven home.

In many parts of the country flights of steps are assembled in a different way and for this reason there are small differences in detail. The steps are built up by inserting a tread at each end, cramping and wedging. All the remaining treads are slipped into their housings from the back and secured. The risers are then inserted, passing *behind* the treads, and wedged and nailed in position. Glued blocks are inserted between tread and riser as a last operation.

Newel posts prepared and fitted in the shop are usually fixed on the job, also handrails and balusters.

The stair is largely a self-supporting unit and consequently

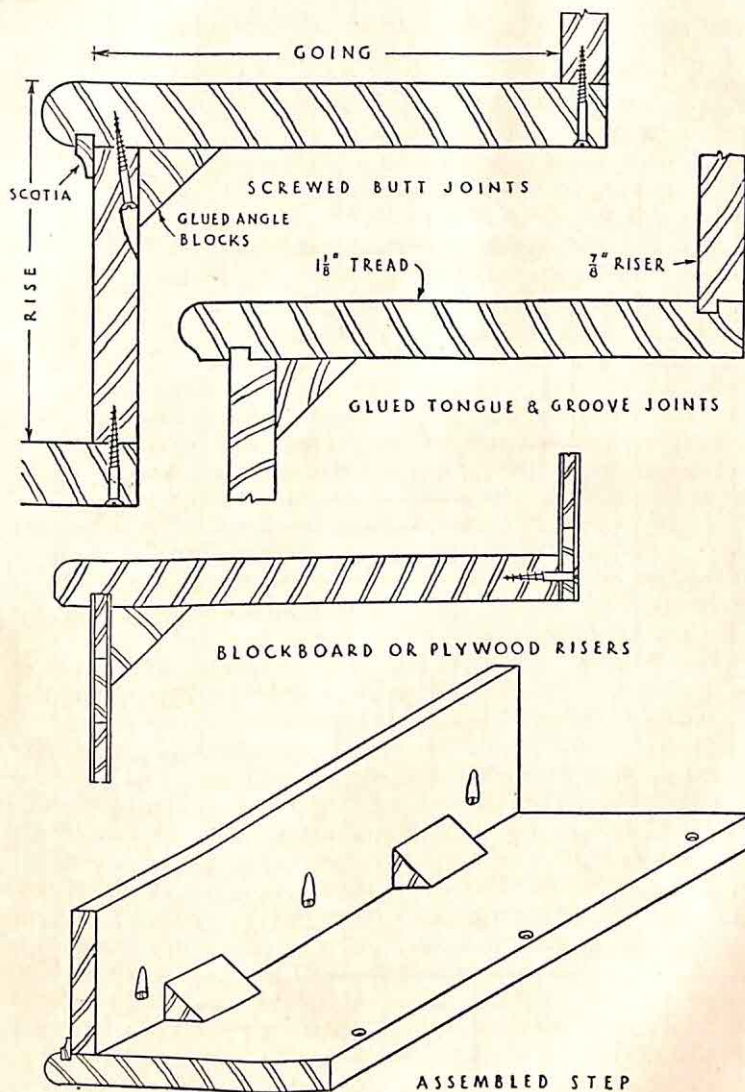


FIG. 116. JOINTING OF TREADS AND RISERS

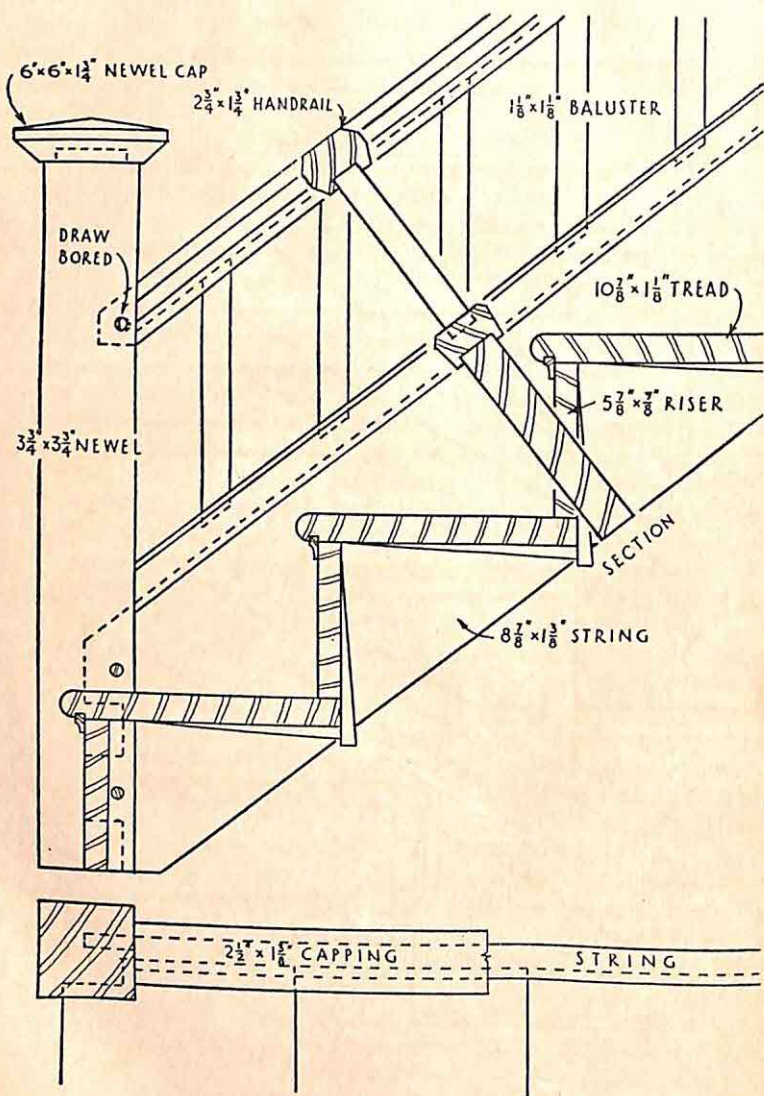


FIG. 117. STAIR CONSTRUCTION: GENERAL ARRANGEMENT

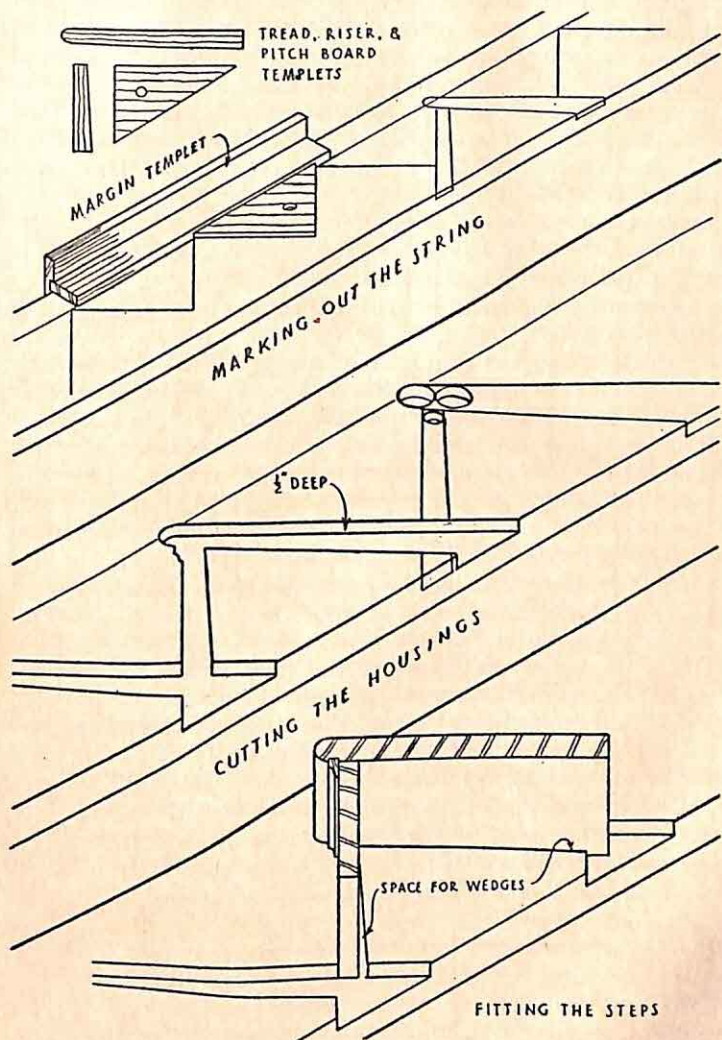


FIG. 118. PREPARATION OF STAIR STRINGS

little fixing should be necessary. A few screws at the top and bottom, and one or two through the wall string into plugs in the brickwork joints, are usually all that is required. Additional support is sometimes given at the middle of the width of the stairs by a carriage piece, placed under the back edges of the steps after the staircase is fixed. Side brackets, forced up tightly and screwed to this carriage piece, support the middle of the treads.

SPACE UNDER STAIRS. The triangular space left under the stairs can be put to several good uses. When left open, it may be plastered on the underside (on grounds fixed by the carpenter) and will provide a convenient space for a perambulator.

By placing a partition immediately beneath the outer string, a cupboard is formed suitable for meters and brooms or food or coal. If the space is used for coal, a door in the outer wall is provided for delivery and another on the inside for taking out supplies; an arrangement which makes for cleanliness and convenience.

The partition may be of breeze or other blocks, or wood framed panelling, called *spandril framing*. This triangular framing provides a valuable exercise for a beginner as it requires neat accurate work on mortise and tenon joints at an angle to the material.

TREADS AND RISERS (Figs. 116 and 117). When the rise and going of each step have been determined by accurate division of the total rise and total going, the design of the treads and risers can be considered. In a good stair $1\frac{1}{4}$ in. material is suitable for treads, 1 in. for risers. At least $\frac{1}{8}$ in. will be removed in planing, rather more if the stuff is machine planed. Assuming a 7 in. rise, the riser will be 7 in. — $1\frac{1}{8}$ in. (thickness of tread) = $5\frac{7}{8}$ in. wide. Assuming 9 in. going, the tread will be 9 in. + $\frac{7}{8}$ in. (riser thickness) + $\frac{3}{8}$ in. (scotia) + $\frac{5}{8}$ in. (nosing) = $10\frac{7}{8}$ in. wide.

The *scotia moulding* is glued into the groove on the underside of the tread, and forms a stop against which the riser can be set while the pocket screws are turned in. Glue-blocks help to strengthen the joint, and temporary braces may be nailed across the ends of the assembled step to keep it square.

Of the alternative methods of construction, the tongue and groove type needs extreme accuracy to be effective, and the

tongues are liable to split off when the tread shrinks. (For this reason, in some parts of the country, the tongue is placed on the back of the tread.) The use of ply or blockboard for risers is a genuine economy device, as the tread need not be so wide; while the $\frac{3}{8}$ in. or $\frac{1}{2}$ in. material for risers is quite a saving on the more usual 1 in. thickness and still possesses great strength.

When the glue is dry, each step is sawn accurately to length and perfectly square ready for fitting into the strings.

STRINGS (Fig. 117 and 118). The string which is fixed to the wall is called the wall string and is usually of $1\frac{1}{4}$ in. material. The outer string should be out of $1\frac{1}{2}$ in. stuff. The width will depend upon the dimensions of the step. Allowing $1\frac{1}{2}$ in. for the margin, the step needs to be supported right to the back edge. It is not necessary to have any margin on the underside.

Setting Out. Templets (Fig. 118) are prepared from plywood or other sheet material for tread, riser and *pitch board*. The latter is a right-angled triangle, the square sides of which are rise and going respectively. A further templet is made T-sectioned, to serve for a margin gauge.

Cutting and Fitting (Fig. 118). Holes are first made at the front end of the housing, and then chiselled out to the lines. This enables sawcuts to be made for removal of the main part of the waste, which is first chiselled approximately and finished accurately to depth with a router. The housing for the scotia moulding is best left until the step is placed in position in order to allow for slight variations.

NEWEL POSTS (Fig. 117). These are supported by the strings and carry the handrails; they are mortised to receive the stump tenons on both strings and handrails. When these joints have been fitted, holes are made for dowel pins, those on the tenon being nearer the shoulder to obtain a draw-bore effect; that is to pull the joint tightly together as the dowels are driven in. The riser face is arranged to be on the centre line of the newel post, and both tread and riser are housed $\frac{1}{2}$ in. deep. No wedge space is allowed, but the riser housing is cut right away to the back edge so that the post can be pushed on to the string tenons.

Capping, Balusters and Handrail. The capping moulding is grooved $\frac{1}{4}$ in. over the string and the balusters are sunk $\frac{1}{2}$ in. into it. At their top ends the balusters are housed in a

groove on the underside of the handrail, and fixed with a fine sloping screw (Fig. 117).

Newel Caps. These may be formed in the solid post or applied as a separate member. Sometimes a knob is turned on the solid or fixed by means of a stout peg. The flat kind may be housed over the top of the post and fixed with screws. Screw-holes may be stopped with putty or carefully matched wood plugs, depending on whether paint, varnish or polish is to be used for finishing.

Assembly and Fixing. A strong bench is placed beneath a stout beam if possible, and on it one string with housings uppermost. The steps are placed (not glued) in position and the other string on them. A stout plank is placed on top, and struts cut between it and the overhead beam, but 2 in. short so that folding wedges can be used to apply pressure. The steps are tested for squareness off the strings, and when all is ready the wedges are glued and driven home—first a tread, then a riser and so on, a mallet and chisel being used to chop spare ends of wedges off to make room for the next. The work is turned over and the process repeated.

Special benches with an overhead frame are used in workshops where a lot of this kind of work is done. Other methods may be improvised with cramps for small jobs.

BULLNOSE AND ROUND-END STEPS (Fig. 119). A pleasing finish is given to a staircase if the bottom newel post is set back one step and the lowest step is returned with a quarter or half circular curve at the end. When setting out these bullnose or rounded steps, it is a good general rule to make all the riser faces coincide with the middle line of the newel post. Scotia and tread will oversail the line.

A special method is needed for building these steps. The tread must be shaped and moulded to the curve and the scotia moulding worked on the edge of flat material 3 in. wide, which will need to be in two or three pieces at the curve.

The riser construction is fairly complicated. A block is built up in three thicknesses screwed together to form the curved end portion. In the case of the bullnose, the three layers are made the same way of the grain, but the half-round block will have the middle layer running in a different direction to the top and bottom ones. The blocks must be carefully shaped to a circular curve having a radius $\frac{1}{8}$ in less than the

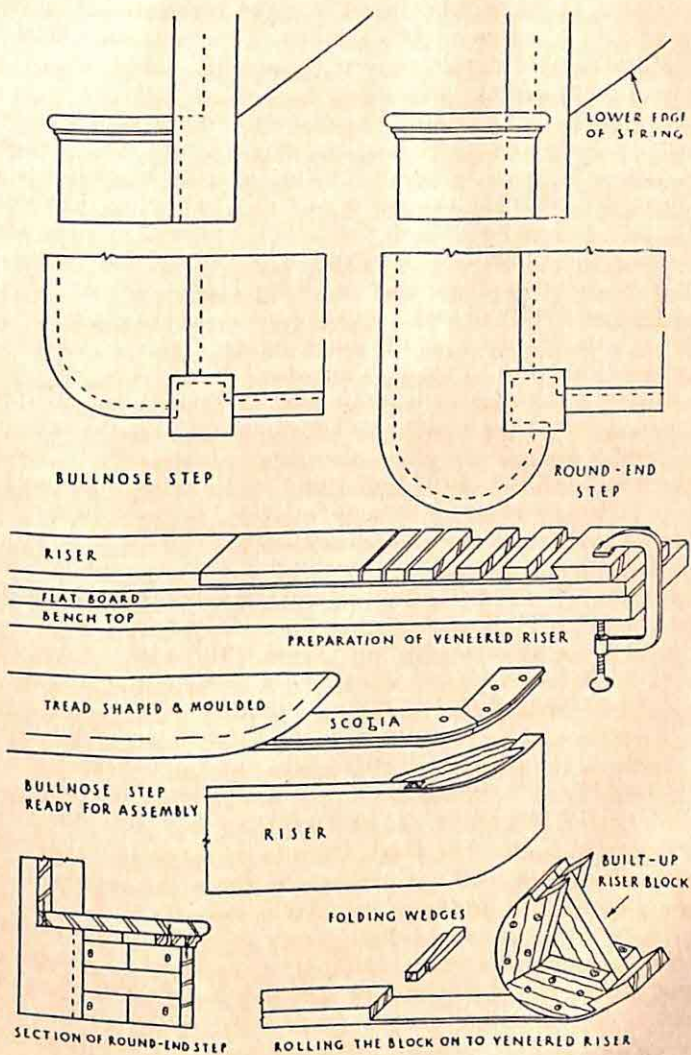


FIG. 119. BULLNOSE AND ROUND-ENDED STEPS

riser face. It is essential that the curve is square off one flat side all the way round. If a smoothing plane is used at right angles (across the depth) to form the outline, a spokeshave can be used for the final shaving.

For the riser (if the job is in softwood) a piece of yellow deal must be carefully selected, free from knots and straight grained. The portion to be bent around the block must be reduced to $\frac{1}{8}$ in. in thickness by carefully removing, first, each alternate inch or so by saw, chisel, and router (Fig. 91); then carefully splitting off the intervening pieces and finishing with finely set rebate and smoothing planes. If there is any doubt about one's ability to saw, groove or plane accurately to depth, it is advisable to fix $\frac{5}{32}$ in. fillets on each side to the base board and remove the last $\frac{1}{32}$ in. with the planes.

Provision must be made on the block for one thick end of the riser to hook on to an underset portion, and for the other to be wedged.

The thin portion of the riser will need thoroughly soaking in hot water or steaming before any attempt is made to bend it; but once this is done, all should go easily. The block should be warmed prior to the glueing operations, and a household iron will sometimes come in useful should the glue become chilled in the process. Screws are put through the block into the thick part of the riser at both ends. All surplus glue should be removed from the face of the riser, as cleaning up subsequent to drying must be kept to a minimum.

The step is assembled by screwing the scotia portion to the riser and its block, and then driving more screws up through the scotia board into the tread. Like other varieties, these curved steps must be everywhere housed $\frac{1}{2}$ in. into the newel post.

SECTION VII

MODERN MATERIALS AND CONSTRUCTION

THE need for economy in time and material, the mass-production of joinery work by machinery, the increasing use of plywood and other types of prepared board and the developments taking place in adhesives, combine to effect great changes in the design, construction, and adaptation of woodwork.

Framed and Panelled Doors. Mortise and tenon joints (whether hand or machine) are really rather wasteful of timber and labour as compared with dowel joints. The relative merits of these two types of joint are a matter of keen controversy among craftsmen; but it may be stated definitely that a dowelled joint to be effective must be very accurately made, carefully glued and cramped and held flat until dry. Given these conditions, dowel-jointed doors are very satisfactory, and a saving of about 14 per cent of timber is effected. This figure is based upon the framing only and may be verified by calculating how much timber is needed to provide tenons as compared with butt joints in a 6 ft 4 in. $\times$ 2 ft 4 in. four-panel door. As a more vivid example, from the timber necessary for 1000 traditional type doors, 1140 could be made by using dowel joints.

Flush Doors. A skeleton frame of comparatively inferior wood is made and a sheet of plywood subsequently glued to both sides. The upright edges are then grooved and a separate edging glued on. This covers the unsightly edges of the plywood. When glass panels are required, as in lift doors, framing members are arranged to frame the opening and the glass is held in position with loose beads, preferably rebated over the face.

Flush doors are stronger than panelled doors for a given amount of material, since the ply skins add considerably to the strength; ordinary panels on the other hand have to be supported by the frame.

Windows. In the Scandinavian countries it is quite usual to find two sets of window frames and sashes in the same opening. The pad of air trapped between is a thermal buffer between outside cold and inside warmth. The frames have to

be made thinner and are therefore of superior timber. The idea of thinner framing has recently been used in this country as a means of saving timber. Since window frames should bear no structural loads, this move is reasonable; it has several additional advantages, including increased width of window board. Moreover, due to modified design of rebates, *standard windows* (as they are known) have greater resistance to rain and wind penetration.

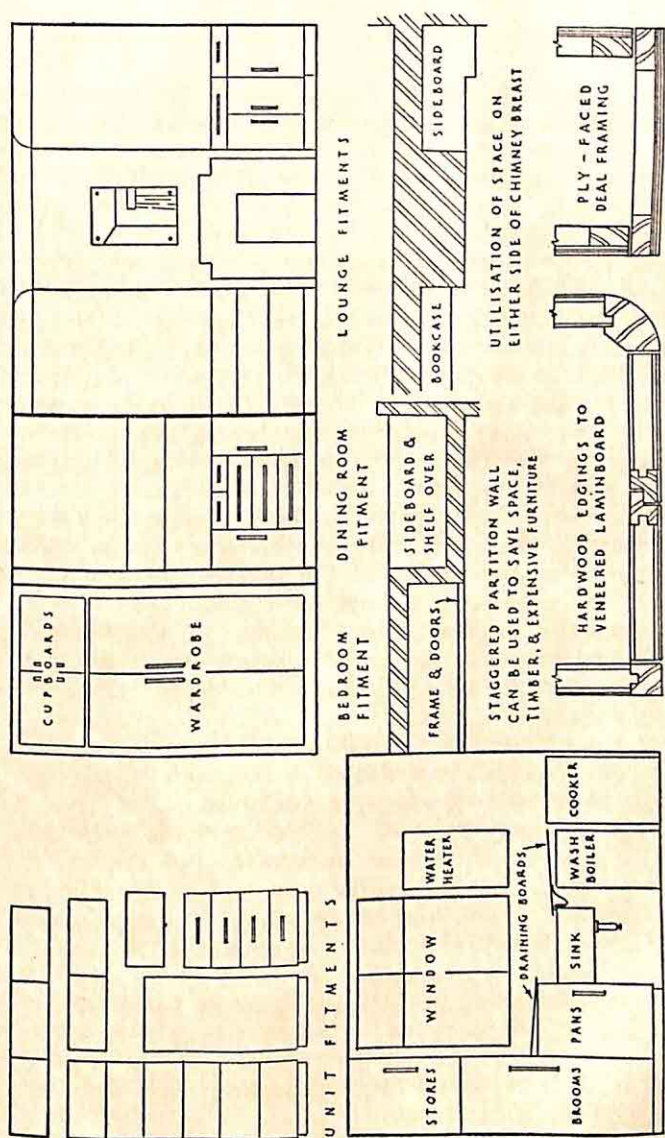
Joinery Fitments (Fig. 120). The days are passing when a house was considered in terms of walls, floors and roof only. Prefabricated homes are hastening the process, the designers realizing that a house without cupboards, wardrobes, drawers and other minimum requirements would merely create fresh problems for the prospective tenants. Much remains to be done in this direction, in order to obviate awkward, bulky and dust-collecting furniture, and the need for employing huge pantehnicons when a family wishes to make a move.

Built-in joinery has for some time been usual in the kitchens of new houses; but the bedroom, dining room and sitting room provide ample scope for the further development of the idea. Why wardrobes, bookcases, sideboards, chests of drawers and the like should be considered as optional extras in traditional houses is somewhat obscure—to fit them as a matter of course would save much unnecessary expense and inconvenience.

Ply and laminboard are readily adaptable to the construction of built-in fitments and need a minimum of expensive framing where used in adequate thickness. For instance, a wardrobe or other cupboard door can be made by sawing a piece of laminboard of suitable size from the sheet and hanging it in the opening. Vertical edging may be desirable where the work is intended for polishing or varnishing. The same material lends itself to beautiful surface treatments in the shape of veneers of decorative woods.

By thoughtful design of the main structure backs and sides, even tops and bottoms, can be omitted from fitments thus making a considerable economy in timber. To use fitments as dividing walls is not altogether satisfactory, as sound travels too readily from room to room.

Laminated and Manufactured Products. Various materials in board form are available, wood being the basic raw material.



THOUGHTFUL ARRANGEMENT OF KITCHEN COMPONENTS

TYPICAL "FLUSH" JOINERY CONSTRUCTION FOR POLISHED & PAINTED WORK

FIG. 120. MODERN MATERIALS: CONSTRUCTION AND USE IN HOUSE FITTINGS

They may be divided into two broad types, hard board and soft fibre boards. The wood may be shredded or pulped directly from the lumber, or may be first used as paper, being subsequently salvaged and used for making the boards.

The harder kinds are compressed to form dense hard-wearing boards suitable for interior panels in passenger transport vehicles and for articles of domestic furniture and equipment. Loose textured boards are more suited for domestic wall boards, insulating boards, etc. Laminated wood boards employing synthetic resin are still not fully exploited, and their resistance to moisture is a factor which may revolutionize wood construction of the future.

By previous steaming of the laminations, wood may be readily shaped to any desired curve; and by glueing and cramping the skins around suitably shaped moulds or formers, useful and graceful shapes are obtained. One great advantage of bentwood products is that wastage of timber is minimized, since curves made in this way do not involve removal of wood in their formation. Scandinavian countries lead the way in bentwood furniture, and very pleasing articles are made in this way.

SECTION VIII

MEASURING, DRAWING, TRACING, LETTERING AND REPRODUCING

THE joiners' setter-out or foreman is often called upon to measure an existing building for alteration or repairs and, from his data, rods or drawings are prepared. The various departments concerned with the work (office, mill, outside

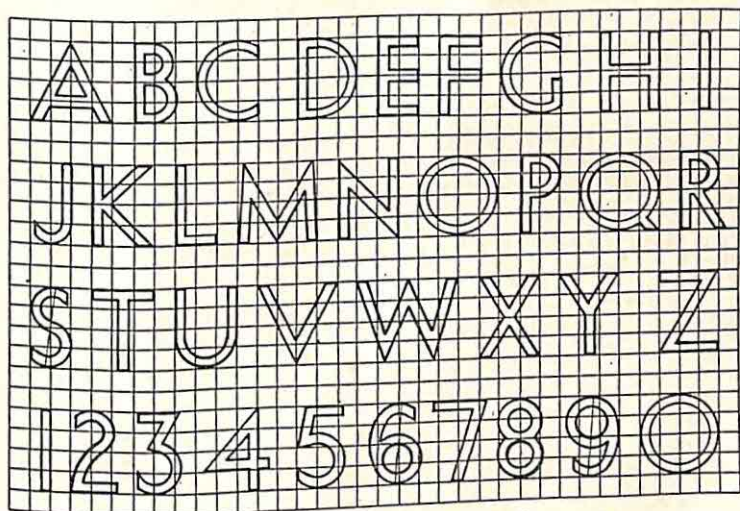


FIG. 121. SETTING OUT OF BLOCK LETTERS

foreman) may need copies of scale drawings and for this purpose a tracing is made on cloth or paper, and blueprints taken off.

To obtain a clear picture of these processes, it is a good plan to practise them oneself. Actually to design joinery work may not prove practicable at this stage, but joinery and associated construction can be measured and reproduced by the means stated. First, a suitable portion of construction should be selected, say a main entrance doorway, a group of cupboards, a teachers' demonstration bench and blackboards and the like.

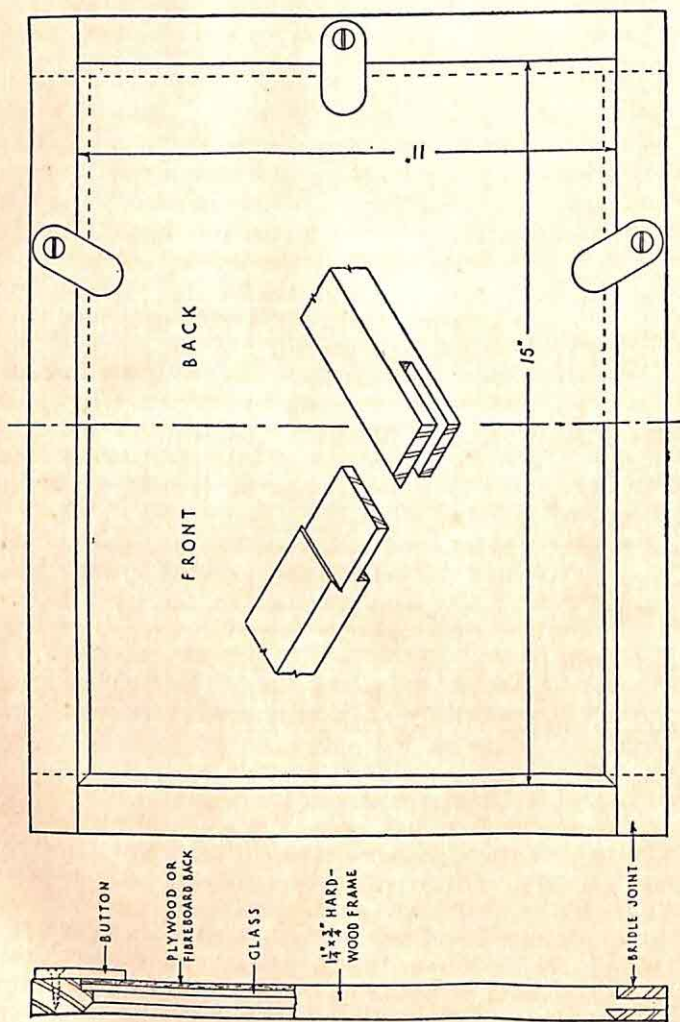


FIG. 122. PRINTING FRAME FOR REPRODUCTION OF DRAWINGS

The usual 2 ft four-fold rule is suitable for small measurements, but may prove tiring for the larger ones. Five-foot two-fold rules are useful on this kind of work, also 6 ft steel tapes. A large sheet of drawing paper or a notebook will be required for dimensioned sketches.

The aim must be to take all essential measurements and details before beginning the scale drawing. In industry numerous trips to the site for forgotten details are costly and inconvenient. When the drawing is complete, a tracing is made on tracing paper or cloth with pen and Indian ink. This would probably be done in a building drawing lesson.

Lettering is important and some simple clear style should be developed. Fig. 121 gives an idea of the best forms and proportions for block letters and numbers.

Blueprinting. Many schools have the arc lamp and other apparatus necessary to do this work, but quite homely apparatus can be improvised if required. Any picture frame will do, though it is more convenient to have available a special frame with a firm back which can be pressed against the glass (see Fig. 122).

The sensitive paper used is ferro-prussiate paper; a piece of this is put behind the tracing and exposed to sunlight. It is important that the light rays strike the glass at right angles. A few trial strips of paper should be tried at exposures varying from 20 sec to 5 min. After suitable exposure, prints are washed in water and hung up to dry. Over-exposed prints may be rescued by washing in a solution of potassium bichromate (the same substance as is used in staining mahogany).

The washing process alters measurements slightly, and blueprints usually bear the legend "figured dimensions to be taken in preference to scaled measurements."

Dry Printing. Other printing processes overcome this disadvantage by obviating any wetting of the paper. Brown-prints for instance are developed and fixed in an airtight box in ammonia fumes. Some of these processes need very accurate timing and lighting, however, and are therefore less adaptable than the homely method described above.

Workshop Drawings. Drawings in frequent use can be duplicated by one of the methods described and may then be made wear- and dirt-resisting by mounting on thick card or plywood.

Thin glue can be used for attaching prints to the backing and for sizing the surface. A coat of church oak varnish applied when the print is dry will impart a washable glazed surface. If card is used, both sides should be sized and varnished alike to prevent curling.

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